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PLAINPICTURE/JOHNER

Kids, who'd have them?

Policies that discourage parenthood are not a smart plan

BECOMING a parent changes your life in many ways, but one thing it probably won't do is make you happier. Despite pervasive cultural messages to the contrary, research suggests that having children makes no net difference to parental happiness and often slightly decreases it (see page 40).

The outlook isn't all bad. In places where welfare provision such as childcare is most generous, parents report higher levels of well-being. That is probably because the woes accompanying parenting are largely driven not by babies themselves but by the financial pressures they impose.

It is ironic that these findings are emerging at a time when social safety nets are being shredded in many Western countries. In the UK, for example, the Sure Start programme launched in 1998 has recently been squeezed despite evidence that it was a success on many measures, including greater life satisfaction for parents.

The parents of older children are similarly being clobbered by UK welfare cuts – to housing benefit for the under 21s, for example, which can make it hard for children to leave home, and to tax credits that boost the income of poorer working families.

It is not necessarily the job of government to promote happiness. But the US Declaration of Independence lists the "pursuit of happiness" as an inalienable human right, Bhutan pursues Gross National Happiness as a measure of success and many other governments including the UK's are experimenting with happiness indices.

You could argue that people who can't afford children should not have them. But as birth rates fall, triggering the prospect of a demographic time bomb, it is surely foolish and short-sighted to actively promote social policies that discourage people from having children. The UK government has already been accused of waging a war on young people. It is also waging a war on parents, and those who would like to become one. ■

Visionary science

PROJECT Prakash in India is about as praiseworthy as it is possible for science to get. Founded by neuroscientist Pawan Sinha, it cures children with treatable blindness and then offers them the chance (no obligation) to participate in its research into vision (see page 28).

Since it started 10 years ago, Prakash has given the gift of sight to nearly 2000 children. The effect on their lives is immense: without treatment only around half would reach adulthood. The project has also contributed a good deal to our understanding of the visual system.

This clever combination of healthcare and research has immense promise in other areas. One is illiteracy: around a third of the world's people cannot read or write. Providing them with an education would be of immense humanitarian value, and also enable researchers to study various aspects of brain function.

The list goes on. Sinha suggests the model could be used to help people with epilepsy, autism and speech impediments, feed millions of malnourished children and screen for diseases in developing countries.

There are probably many more possibilities. We need more people like Sinha to identify them and bring them to fruition. ■

Drilling to start in Alaska

THE debate on global warming is heating up in Alaska.

US president Barack Obama embarked on a trip around the state this week, observing the impact of climate change and calling for solutions. But last month his administration granted Shell permits to drill for oil off Alaska's coast, risking calls of hypocrisy from environmental activists.

In 2013, Shell was forced to suspend activity in the Arctic after technical difficulties, including an offshore drilling barge that ran aground, narrowly avoiding an environmental disaster.

Despite protests and proposed counter-legislation, the company was granted permits to resume drilling in the Chukchi Sea on 17 August.

Obama defended the decision on Saturday, saying it was a necessary measure while the US looks toward renewable energy. "Even as we accelerate this transition, our economy still has to rely on oil and gas," he said.

US government officials and Shell have stated that they are committed to high safety standards. Earlier this year, the Obama administration also asked Congress to protect 5 million hectares of Alaska's Arctic National Wildlife Refuge.

But some environmental activists are concerned about the impact the drilling will have on polar bears, walruses and other animals that live in the area. Leah Donahey of the Alaskan Wilderness League says there's no guarantee that the region won't see a spill in the future.

AP PHOTO/ANDREW HARNIK

Mixed messages

The wrong drugs

IT WILL come as no surprise to relatives. Doctors are resorting to powerful psychotropic drugs, such as antipsychotics and antidepressants, to calm patients with intellectual disabilities – even if they don't have a history of mental illness.

"Sedating people may dampen the challenging behaviour, but won't identify the source of the frustration," says Rory Sheehan of University College London.

Sheehan and his colleagues collected data from 571 doctors' surgeries in the UK over five years. They identified 33,016 people with intellectual disability, 63 per cent of whom were prescribed some kind of psychotropic drug by the end of the study, despite just 34 per cent of the group being diagnosed with a mental illness.

"A person may be banging their head because they have an earache. Antipsychotics won't help"

Specifically, 9135 people were given antipsychotic drugs, although 70 per cent of them didn't have a record of the kind of severe mental illness, such as bipolar disorder or schizophrenia, for which these drugs are usually prescribed. Those with a record of "challenging behaviour" were more than twice as likely as those without to receive the medication (*BMJ*, DOI: 10.1136/bmj.h4326).

"It's possible the doctors are prescribing them to manage the behaviour, but there's very little evidence that these drugs work in these situations," says Sheehan. A person may be banging their head on the table because they have an ear infection, for example, in which case, an antipsychotic drug wouldn't solve the problem.

"Fundamental changes must be delivered, addressing a culture of 'chemical restraint' and replacing it with individualised behaviour support," says Viv Cooper at the UK Challenging Behaviour Foundation. "We've heard from families time and time again about their loved ones being given high levels of antipsychotic medicine," says Dan Scorer at Mencap. "In many cases they report serious side effects."

Vulture decline

VULTURES are soaring in popularity – but that's not good news. Big birds are appearing on hunters' lists for the bushmeat trade, and vultures are their new favourite.

Researchers visited hundreds of bushmeat stalls at 67 markets in 12 countries across west and central Africa, and found 52 species of vulture and other raptors for sale. More than a quarter of species found are classified as near-threatened, vulnerable or endangered on the International Union for Conservation of Nature's Red List (*Oryx*, doi.org/68h).

Team member Ralph Buij of Wageningen University in the Netherlands estimates that more than 6000 of these birds are traded across west Africa each year, including around 1000 endangered hooded vultures.

"These are long-lived birds that reproduce slowly. They are being largely wiped out in west Africa," says study co-author Darcy Ogada of the National Museums of Kenya.

Shame of Europe's e-waste

IT STINKS. A two-year investigation into Europe's electronic waste found that most of it is stolen, mismanaged, illegally traded or thrown into landfill.

The European Union has guidelines on how to dispose of unwanted electronics, carefully recycling the components of equipment such as computers, household appliances and medical devices. But according to a report by the United Nations University and INTERPOL, only 35 per cent of such waste conformed in 2012.

Criminals absconded from Europe with 1.3 million tonnes of equipment, such as laptops, circuit boards and valuable components from fridges. An additional 4.7 million tonnes of electronics were mismanaged or illegally traded inside Europe.

The loss of functional components or the precious metals inside costs the European Union up to €1.7 billion each year, the report says. It also means that toxic materials aren't being disposed of safely.

Newer horizon

THE Pluto-chaser has a new port of call. Fresh from July's fly-by of the dwarf planet, NASA has chosen a possible target for the New Horizons spacecraft to pass on its way out of the solar system.

"The rock's surface could provide a pristine record of the composition of the outer solar system"

The object, named 2014 MU69, is estimated to be between 25 and 45 kilometres across. The team hopes its surface will provide a pristine record of the composition of the Kuiper belt – the outer area of the solar system it shares with Pluto and other icy bodies. It is a good candidate for preserving the region's history as it is too small to have been reshaped by geological processes, and far enough from the sun to have maintained its original make-up.

2014 MU69 is about 200 million times fainter than can be seen with the naked eye. It was spotted last June with the Hubble space telescope after two weeks of observation. That search yielded one other possible destination for New Horizons after Pluto, but 2014 MU69 is easier to reach.

If the extra trip is approved, the spacecraft will start burning fuel to change direction in October and November en route to an expected fly-by on 1 January 2019.

ANDREW MCCONNELL/PANOS

Find the money

PASCAL ROSSIGNOL/REUTERS/CORBIS

Useless catch?

Deep-sea trawl ban

HOW deep is too deep? Europe's most threatened ecosystem – the deep seabed – may get some relief this week when European Union officials discuss proposals on banning trawling below 800 metres. But are the proposals ambitious enough?

Most fishing takes place on the relatively shallow continental shelves. But as catches fall, fishers have increasingly targeted the deep sea, where many fish breed

"The question now is whether Europe's fisheries ministers will accept the new evidence"

slowly – making them vulnerable to overfishing – and trawl nets dragged over the seabed destroy fragile ecosystems. Examining data from trawl surveys, Joanne Clarke at the University of Glasgow, UK, and her team found that the number of species in catches – and the percentage of a catch that is commercially worthless – rises sharply below 600 metres. If trawling below this depth was banned, biodiversity would be protected with minimal loss to fisheries, they say (*Current Biology*, doi.org/66n).

This week's EU proposal, backed by France, puts the limit at 800 metres, but a 600 metre limit would also protect 85 per cent or more of corals, and all of the other fragile ecosystems there, says Matt Gianni of the Deep Sea Conservation Coalition in Amsterdam.

The question now is whether Europe's fisheries ministers – who have a track record of disregarding scientific advice – will accept the evidence.

No tetanus threat

ANOTHER public health win for India. Just over a year on from eliminating polio, the country has declared that tetanus is no longer a threat to mothers and newborns, the groups most at risk.

Tetanus is a bacterial infection often contracted when women give birth in unhygienic conditions. In 1988, it killed up to 160,000 young children in India.

The spores exist in soil worldwide, so the disease will never be eradicated, but vaccination and good hygiene can bring cases down to such a level that the disease is considered eliminated. This is what has happened in India, the prime minister announced last week.

As well as vaccinating pregnant women, the initiative – part of a global campaign that began in 1999 – saw women paid to deliver in a hospital or given sterilised delivery kits for home births.

60 SECONDS

Second time unlucky

Can you trust the latest psychology study? Perhaps not. Researchers were able to replicate just 39 of 100 studies published in three journals in 2008. Originally, 97 per cent of the results were statistically significant, the second time around just 36 per cent were (*Science*, doi.org/68c).

Invisible threat of roads

The noise of a road drives wildlife away – and makes the animals that stay less healthy. Researchers built a phantom road through the Boise Foothills in Idaho, pumping out the sound of traffic during the day using loudspeakers. They found that 31 per cent of the bird population left, and those that remained lost weight (*PNAS*, doi.org/679).

Dutch climate appeal

The Dutch government is to appeal against a district court ruling in June ordering it to cut emissions of greenhouse gases to 25 per cent below 1990 levels by 2020 – faster than it had planned. But it will also begin implementing the court's ruling while the appeal is under way.

Reusable satellites

Two lost navigation satellites have found a new lease of life. Galileo 5 and 6 were launched in August 2014 as part of the European alternative to GPS, but a rocket fault left them stuck in the wrong orbit. Now they will be repurposed to measure the slowdown of time due to Earth's gravitational field, as predicted by Einstein's theory of relativity.

Sleep, don't sneeze

Clock up fewer than six hours of sleep a night? You are more likely to catch a cold than people who spend more than seven hours a night in the land of nod. The results come from a study that involved giving 160 people nasal drops containing the cold virus. The virus was four times as likely to take hold in those who slept for six hours or less (*Sleep*, doi.org/68b)

JULIE GUICHES/PICTURETANK

It's all as strange as it seems

Quantum weirdness is reality

A groundbreaking experiment proves Einstein wrong, says **Jacob Aron**

IT'S official: the universe is weird. Our everyday experience tells us that distant objects cannot influence each other, and don't disappear just because no one is looking. Even Albert Einstein was dead against such ideas because they clashed so badly with our view of the real world.

But it turns out we are wrong – the quantum nature of reality means, on some level, these things can and do happen. A groundbreaking experiment puts the final nail in the coffin of our ordinary view of the universe, settling an argument that has raged for nearly a century.

Teams of physicists around the globe have been racing to perfect this experiment for decades. Now, a group led by Ronald Hanson at Delft University of Technology in the Netherlands has finally cracked it. "It's a very nice and beautiful experiment, and one can only congratulate the group for that," says Anton Zeilinger, head of one of the rival teams at the University of Vienna, Austria. "Very well done."

To understand what Hanson and his colleagues did, we have to go back to the 1930s, when physicists were struggling to come to terms with the strange predictions of the nascent science of quantum mechanics. The theory suggested that particles could become entangled, so that measuring one would instantly influence the measurement of the other, even if they were far apart.

What's more, it also suggested that, prior to being measured, a particle's properties only exist in a fuzzy cloud of probabilities.

Nonsense, said Einstein, who famously proclaimed that God does not play dice with the universe and called entanglement "spooky action at a distance". He and others favoured the principle of local realism, which broadly says that only nearby objects can influence each other and that the universe is "real" – observing it doesn't bring it into existence by crystallising vague probabilities. They argued that hidden variables at some deeper layer of reality could explain quantum theory's apparent weirdness.

"Even Einstein was dead against quantum ideas because they clashed with our view of the real world"

On the other side, physicists like Niels Bohr insisted that we accept the new quantum reality, because it explained problems that classical theories of light and energy couldn't handle.

In the 1960s, the debate shifted to Bohr's side. John Bell, a physicist at CERN, realised there was a limit to how connected two particles' properties could be if local realism was to be believed. He formulated this insight into a mathematical expression called an inequality. If tests showed that the connection between particles exceeded the limit he set, local realism was toast.

"This is the magic of Bell's inequality," says Johannes Kofler, a member of Zeilinger's team. "It brought an almost purely philosophical thing, where no one knew how to decide between two positions, down to a thing you could experimentally test."

And test they did. Experiments

have been violating Bell's inequality for decades, and the majority of physicists now believe Einstein's views on local realism were wrong. But doubts remained. All prior tests were subject to potential loopholes, leaving a gap that could allow Einstein's camp to come surging back.

"The notion of local realism is so ingrained into our daily thinking, even as physicists, that it is very important to definitely close all the loopholes," says Zeilinger.

A Bell test begins with a source of photons, which spits out two at a time and sends them in different directions to two detectors, operated by a hypothetical pair conventionally known as Alice and Bob. The pair have chosen the settings on their detectors independently so that only photons with certain properties can get through. If the photons are entangled, they can influence each other and repeated tests will show a stronger pattern between Alice and Bob's measurements than local realism would allow.

But what if Alice and Bob are passing unseen signals – perhaps through Einstein's deeper hidden layer of reality – that allow the detectors to communicate? Then you couldn't be sure that the particles are truly influencing each other in their instant, spooky way. This is known as the locality loophole, and it can be closed by moving the detectors far enough apart that there isn't enough time for a signal to cross over before the measurement is complete. Previously, Zeilinger and others did just that, including shooting photons between two Canary Islands 144 kilometres apart.

Close one loophole, though, and another opens. The Bell test relies on building up a statistical picture with repeated experiments, so it doesn't work if your equipment doesn't pick up enough photons. The problem gets worse the further you separate the detectors, seeing as photons can get lost on the way. So moving the detectors apart to close the locality loophole begins to widen the detection one.

"There's a trade-off between these two things," says Kofler. That meant hard-core local realists always had a loophole to explain away previous experiments – until now.

"Our experiment realizes the first Bell test that simultaneously addressed both the detection loophole and the locality loophole," writes Hanson's team in a paper detailing the study.

In this set-up, Alice and Bob sit in two laboratories 1.3 kilometres apart, far enough to close the locality loophole.

Each laboratory has a diamond containing an electron with a property called spin. The team hits the diamonds with randomly produced microwave pulses. This makes them each emit a photon that is entangled with the electron's spin. These photons are sent to a third location, C, where a device clocks their arrival time.

If photons arrive from Alice and Bob at exactly the same time, the two electron spins become entangled with each other. So the electrons are now entangled across the distance of the two labs – just what we need for a Bell test. What's more, the detectors observing their spin are of high enough quality to close the detector loophole.

But the downside is that few pairs of photons arrive at C together – just a few per hour. The team took 245 measurements, so it was a long wait.

The result was clear: they detected more highly correlated spins than local realism would allow (arxiv.org/abs/1508.05949v1). The weird world of quantum mechanics is our world.

"If they've succeeded, then without any doubt they've done a remarkable experiment," says Sandu Popescu of the University of Bristol, UK. But he points out that most people expected this result – "I can't say everybody was holding their breath to see what happens."

What's important is that these kinds of experiments drive the development of new technology like quantum cryptography, he says. Networks that use quantum properties to guarantee secrecy are already springing up across the globe, but the loopholes are potential bugs in the laws of physics that might have allowed hackers through. "Bell tests are a security guarantee," says Kofler. You could say Hanson's team just patched the universe.

There is one loophole left for local realists to cling to, but no experiment can ever rule it out. What if there is some kind of link between the random microwave generators and the detectors? Then Alice and Bob may think they are free to choose the settings on their equipment, but hidden variables could interfere with the choice and thwart the Bell test.

"The results of the experiment were clear: the weird world of quantum mechanics is our world"

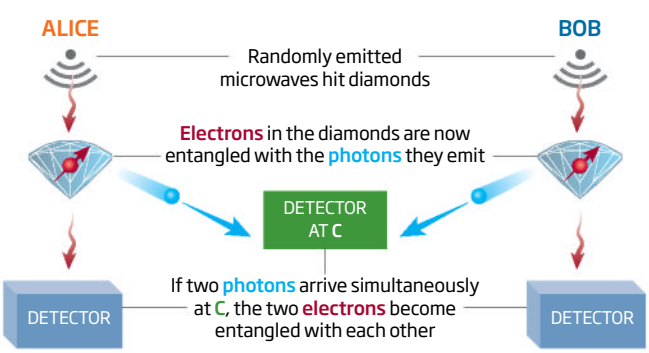
Hanson's team notes this is a possibility, but assume it isn't the case. Zeilinger's experiment attempts to deal with this freedom of choice loophole by separating the random number generators and detectors, while others have proposed using photons from distant quasars to produce random numbers, resulting in billions of years of separation.

None of this helps in the long run – if the fate of the universe is predetermined, with the flutter of every photon set in stone, no one would ever have a choice about anything. "The freedom of choice loophole will never be closed fully," says Kofler.

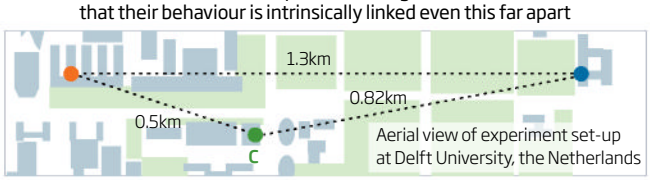
What would Einstein have made of this result? Unfortunately he died before Bell proposed his inequality, but he would likely be enamoured with the lengths people have gone to prove him wrong. "I would give a lot to know what his reaction would be," says Zeilinger. "I think he would be very impressed." ■

Quantum leap

Looking at pairs of entangled particles can tell us whether the world works in a quantum mechanical way. Previous tests of quantum reality have been subject to loopholes - but these measurements are high-enough quality and the detectors are far-enough apart to prove the universe really is weird



Measurements of these pairs of entangled electrons show that their behaviour is intrinsically linked even this far apart



What to do when murder goes viral

Sally Adee

IT IS now possible to watch footage of someone being murdered on your Facebook feed, sandwiched between a holiday sunset selfie and a cat playing the piano. That's not just bizarre and unpleasant: it could encourage people to commit such acts more often.

The latest shareable carnage is the killing of Virginia local television reporters Alison Parker and Adam Ward, who were shot last Wednesday by a former colleague. After the murder, the shooter orchestrated a full social media publicity roll-out, including a manifesto and the video he had taken of the shootings, before killing himself a few hours later. The shooter's Twitter profile accrued more than 23,000 followers, the video went viral on Facebook and was compressed into shareable gifs for easier dissemination.

Some considered sharing these images an ethical imperative. "Our society unfortunately needs vivid reminders of the awesome, life-stopping power of firearms," wrote Brian Beutler on The New Republic website.

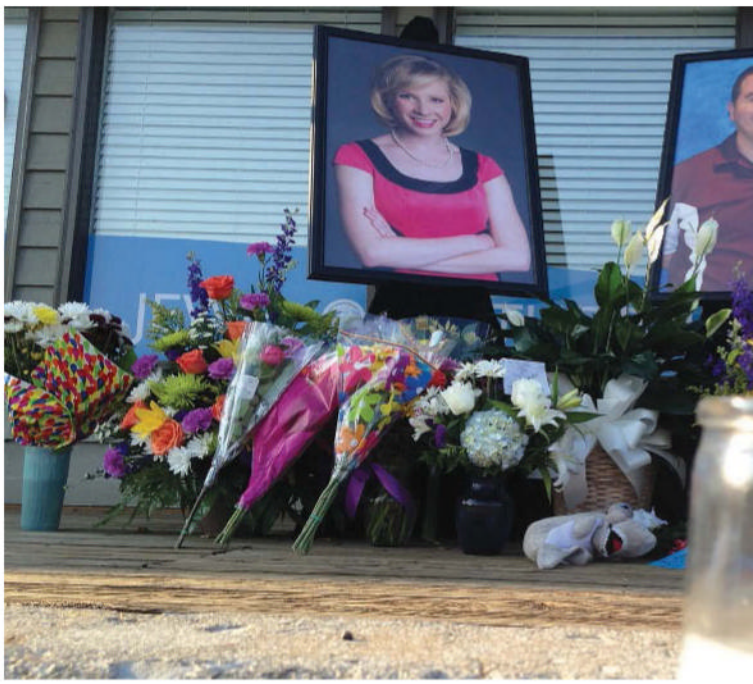
But research so far suggests that might not be such a good idea.

There is already strong evidence that suicide is contagious, and this has led many media outlets to voluntarily censor their coverage. "Research shows a clear link between media representation and an increase in copycat suicide," says Alex Mesoudi at the University of Exeter, UK.

Does media coverage make people more likely to commit murder, too? Although some shooters, including the one in Virginia, cite previous incidents as inspiration for their crimes, research has so far been lacking, partly due to a general resistance to gun control in the US (see "Shhh! Don't mention the killing", below). Now, the first study to look at the incidence of mass shootings, has found that they, too, are contagious (*PLoS ONE*, doi.org/67k).

Sherry Towers at Arizona State University in Tempe and her colleagues investigated the patterns in these events using a model previously used to describe the spread of epidemic diseases, jumps in stock markets, and earthquake aftershocks. They found that the occurrence of a mass killing – which they defined as the death of four or more people – meant that another shooting was significantly more likely to happen within the next 13 days.

"The occurrence of a mass killing makes another more likely to happen within the next 13 days"



The body count of a given shooting is not important in itself, Towers suggests. It is whether a shooting receives local or national news coverage. "It's the attention, not the numbers," she says. The reason for this, she thinks, is that an event reported in the national media is able to reach the very limited population that might potentially commit a copycat crime.

"There aren't many people susceptible to this contagion, maybe one in a million," she says. "You have to have a psychological 'immune system' that is vulnerable to being infected by these kinds of images", the way people with compromised immune systems catch the flu. To do this, a story has to go national.

Towers's research did not distinguish between traditional and social media. But other studies indicate how social sites can give a story national reach even without official media coverage. For example, Facebook's reach dwarfs that of any traditional media channel: making something go viral with Facebook's 1.49 billion members does not depend on a national news organisation deeming it newsworthy.

So social media gives the means, but why do people transmit this material? Why did people share the video of the Virginia shooting, or the videos and manifestos posted by the killer of six people last year in Santa Barbara, California, or the horrific images and videos

SHHH! DON'T MENTION THE KILLING

It's not every day that a scientist undertakes ground-breaking research with no funding at all. But that's what Arizona State University statistician Sherry Towers had to do in order to produce the first study on the contagion of mass shootings in the US (see main story). "We basically had to do this in our spare time," she says.

That's because since 1997, the US Congress has restricted research into mass shootings. A bill passed in 1996 stipulated that no Centers for Disease Control and Prevention funding could be used to advocate or promote gun control. This was vague enough to ensure that research into the effects of gun violence has never been funded since.

The idea for the study struck Towers when a meeting at Purdue University was cancelled due to a school shooting there. "I thought, wait a second, this is the fourth shooting [in the US] this week," Towers says. Was this merely a blip, she wondered, or were these events becoming more frequent?

A national database recording all shootings would make it easier to find out, but the funding restrictions also apply here. However, a congressional research report released last month did conclude that mass shootings are on the rise and highlighted the need for more research to inform policymakers.

AP PHOTO/JONATHAN DREW

Copycat crime?

broadcast by ISIS?

There is evidence that social media not only makes it easier to spread information, but it changes the dynamics of its spread. A clue to why this might be so comes from research into how we interact with others online. In our daily lives, we generally adapt our behaviour according to the social situations we find ourselves in. But online, these various aspects of our persona flatten into a single public face – a phenomenon known as context collapse. Could information itself be subject to a similar flattening?

The Facebook feed already collapses gossip, advertising, entertainment, world news and games into a single homogenised stream of content. That could make it easier to share without thinking too hard about it, says social media researcher Danah Boyd at Microsoft Research.

"They share because they're affected by what they see," she says. "They aren't thinking about the context in which their post will appear. They aren't thinking about how publicity is desired by those producing the videos. They are thinking about their own emotions and the people they know who they think need to know."

More ominously, it might be that we share horrifying content because its producers are getting better at packaging it. Research has shown that gossip is king on social media, and advertisers, marketers and publishers quickly cottoned on and changed the way they presented information. Thomas Poell at the University of Amsterdam in the Netherlands says this explains the success of headlines like "You won't believe what happened next" and "One weird trick".

His research suggests activists learned from marketing. "Our main conclusion is that social platforms strongly focus public attention on the spectacular, comical and violent aspects of protest," he says (*Information, Communication & Society*, doi.org/67m).

Shooters and ISIS have turned the social media activism model to their advantage. "Obviously these people are not similar to activists," Poell says. "But some of the mechanisms we have identified in our research on activist social media communication do play a role."

Once virality hits a certain threshold, the number of people reposting content overwhelms any human attempts to review and censor them. Facebook and Twitter removed the Virginia gunman's account within minutes, but it was too late. The video of Parker and Ward's last moments will likely never be scrubbed from the internet.

So as with suicide, so for murder. Whether through traditional media or social share, viral popularity moves the spark one step closer to the powder keg.

And if that video does pop up in your Facebook feed? "Watching is up to the individual," says Towers. "But it's worth remembering that you can never unsee something." ■

Chatty bugs take cellular machines to new heights

HARDER, better, faster, stronger. When cells cooperate, they achieve the otherwise impossible, something that could eventually lead to smart cancer therapies.

Instead of engineering cells to work as tiny individuals, researchers are working on a new class of cellular machines that "talk" to each other – and behave in more sophisticated ways. Put simply, synthetic biology is going multicellular.

"Initially, there was more emphasis on engineering individual cells and real progress was made," says Ron Weiss at the Massachusetts Institute of Technology. "But now there are an increasing number of demonstrations showing what's possible with multiple cells. It's another dimension."

The latest example comes from a team led by Matthew Bennett at Rice University in Houston, Texas. They developed a system that at its simplest encourages cooperation between two distinct populations of *Escherichia coli*. One produces an "activator" signalling molecule that triggers the bacteria in the second population to produce a "repressor". This signal can travel the other way and turn off production of the activating molecule.

The team also engineered the *E. coli* so they would fluoresce depending on the strength of the signals. What's interesting is the sophisticated way the two

"Sophisticated behaviour occurs only when the different *E. coli* strains communicate"

populations respond. They found that about every two hours, the cells in both populations fluoresced more and more, before gradually fading away again (*Science*, doi.org/66b).

"If you grow just one of these strains by itself, nothing happens," says Bennett. Only when the two populations communicate does this oscillating behaviour appear. Such an oscillator could be used as a molecular timer but more significantly, it is proof of principle of the complexities that emerge when cells – whether mammalian or microbial – are persuaded to communicate.

And interacting systems could prove very useful indeed, says Joshua Leonard at Northwestern University in Evanston, Illinois. For instance, a cellular population is collectively much more aware of its surroundings than any individual cell. "You might get more accurate processing of environmental signals and therefore more robust decision-making," says Leonard. That could make multicellular synthetic biology useful in industry.

For example, unicellular microbial systems already churn out chemicals and pharmaceuticals in fermentation vats. Perhaps a multicellular version could continue to work efficiently even if conditions in the vats began to alter.

Multicellular synthetic biology could also become a big player in medicine. "The medium-term goal is working with systems like the gut microbiome, in which we can deploy cells to report about or alter their environment," says Bennett. There has already been some success using engineered cells to patrol our guts. These cells might become even better at diagnosis and treatment if they begin to communicate with one another and with other microbes in the gut.

Cancer could be another target. "You might want your engineered cells to figure out whether they are sitting next to a tumour or not – and if so, release a drug," says Leonard, who recently described a technology that will allow mammalian cells to interact with multicellular networks in their environment (*ACS Synthetic Biology*, doi.org/659).

"It's clear that fully exploiting the unique capabilities of living cells will ultimately require us to go multicellular," says synthetic biologist Michael Elowitz at Caltech in Pasadena. Colin Barras ■

INSIGHT Ebola vaccine

Ban on chimp tests may kill wild apes

Debora MacKenzie

AN ANIMAL welfare victory in the US may prove to be a conservation catastrophe in Africa. Tests of a promising oral Ebola vaccine that could protect wild apes may be abandoned this month when a ban on the use of chimpanzees in biomedical research comes into force.

An outbreak of the deadly Ebola virus has swept across west Africa over the past 17 months, killing more than 11,000 people. Humans are not the only great apes at risk. The virus has killed chimps elsewhere in Africa, and, according to estimates by Peter Walsh at the University of Cambridge, the virus has wiped out a third of the world's gorillas, leaving the eastern lowland gorilla critically endangered.

Infected ape carcasses have, in turn, triggered further human outbreaks in central Africa. Walsh thinks the virus is now spreading across central Africa towards previously unaffected gorillas.

But there is hope. Last year, Walsh reported that an injectable vaccine made of viral fragments prompted chimps to produce antibodies at levels that protected vaccinated macaque monkeys from Ebola. For ethical reasons, chimps cannot be exposed to the virus to test vaccines. However, human trials of Ebola vaccines being carried out in west Africa mean researchers can now compare antibody levels in vaccinated chimps with those known to protect humans.

Wild animals are difficult to inject, however. Trials using darts to vaccinate wild gorillas for measles have recently had some success, says Walsh. Oral vaccines would be easier. Last month, he started trials in chimps of a weakened rabies strain carrying a surface protein from the Ebola virus.

The rabies strain is safe: it is scattered across western Europe to keep the region clear of rabies spread by foxes. A company in California has now found a way to incorporate the vaccine into a heat-stable foam, says Walsh, which, mixed with honey, could potentially be eaten by African apes.

His team is administering the vaccine orally to six chimps at the New Iberia Research Center in Louisiana, and injecting it into four more. They will assess the chimps' health and antibody levels – but Walsh says further work with captive chimps is needed before the vaccine can be used in the wild.

And that's the problem. Work must end on 15 September, when a ban by the US Fish and Wildlife Service on the use of captive chimps for biomedical testing comes into force. The move follows a long-running campaign by animal welfare groups to have the species reclassified as endangered.

Research that benefits chimps will still be permitted. Walsh's vaccine research meets that criteria, but there is unlikely to be anywhere to carry it out. None of labs currently housing chimps for research has applied for a permit. Walsh thinks they fear that the negative publicity will jeopardise other, more extensive work with monkeys.

Christopher Whittier of Tufts University in Grafton, Massachusetts, believes a vaccine can be developed using research in wild apes if necessary. "We can get a safe and effective Ebola vaccine for apes fairly quickly," he says. "Someone with enough money – like single digit millions – could take credit for saving all the African ape species."

But Walsh thinks it will require captive chimps. "Disease is now a major threat to the survival of our closest relatives," says Walsh. "It is immoral not to intervene if possible." It is ironic that liberating chimps from labs could make that harder. ■

ERIC BACCEGA/NATUREPL

No time to waste

Blind spots wane if you stare at circles

WE HARDLY notice our blind spots, but it seems we can shrink them if we want. It just takes a bit of practice.

If you draw two dots about 10 centimetres apart, close your right eye, and look at the right dot from about 30 centimetres away, you will notice the left dot seems to vanish. That's because the dot is being focused on to a spot in your left eye with no photoreceptors – where the optic nerve joins the retina. You don't normally notice it because your brain fills in the gap based on what you see around it.

But people often report a gap in their field of view that is bigger than can be accounted for by the retinal blind spot, says Paul Miller at the University of Queensland in Brisbane, Australia. This set his team wondering whether the gap could be reduced.

They devised software that displays a circle slightly bigger than the hole in someone's visual field. The circle has stripes within, and volunteers were asked which direction these moved in.

The circle's size was adjusted to be just large enough for participants to get the direction right about 70 per cent of the time – much better than by chance. Over time, volunteers were able to retain this level of accuracy even after the circle had shrunk by about 10 per cent. "People developed sensitivity to things they apparently could not see at the beginning of the training," says Miller (*Current Biology*, doi.org/678).

"If we can train people to be more sensitive to localised blindness, we might improve their driving"

Only 10 volunteers took part, and Miller says the training wouldn't improve the tennis of someone with good sight, for example. But it might help those with visual impairments caused by conditions like age-related macular degeneration.

"If we can train people to be more sensitive to movement in and about regions of localised blindness, we might improve performance when doing important tasks like driving a car," he says. Michael Slezak ■

TUI DE ROY/NATUREPL

Pass the mosquito spray

Finches discover insect repellent

Agata Blaszczak-Boxe

BITE me. Stowaway mosquitoes and parasitic flies brought to the Galapagos Islands on tourist planes pose a deadly threat to the native finches. But the iconic birds – famously studied by Darwin – are fighting back.

The songbirds are plagued by disease-carrying mosquitoes and by the parasitic fly *Philornis downsi*, whose larvae can kill entire broods of young birds. The fly lays its eggs at the base of a finch nest, and when the larvae emerge they suck the blood of the nestlings.

"There is often 100 per cent mortality in nests," says Charlotte Causton of the Charles Darwin Foundation in Puerto Ayora on Santa Cruz Island.

Sabine Tebbich of the University of Austria in Vienna and her colleagues noticed that birds from four species of Darwin's finches were picking leaves from a Galapagos guava tree, *Psidium galapageium*, and rubbing them into their feathers. The leaves turned out to repel mosquitoes and inhibit the growth of the parasitic larvae, the team reported last month at the Behaviour 2015 meeting in Cairns, Australia.

Other birds and animals around the world are known to rub their feathers or fur with plants to protect themselves from insects and parasites, but observations of this behaviour in birds are mostly anecdotal, says Causton.

"This is the first time that Darwin's finches or any other species of Galapagos songbird have been reported conducting this kind of behaviour," she says.

"It would be a rapid and novel evolutionary response to selective pressure. Pretty darn cool"

The adaptation of the finches to many different ecological niches, which elsewhere are usually filled by other birds, helped inspire Charles Darwin's theory of evolution by natural selection.

The finches already have a reputation for being innovative. "They show a lot of behaviours that passerine birds don't typically show," says Andrew Hendry of McGill University, Montreal, Canada.

For example, vampire finches have figured out a way to supplement their diet with an iron-rich treat: drops of blood from seabirds. They peck at the skin around the base of the larger birds' feathers until they draw blood. Another species, the woodpecker finch, uses twigs or cactus spines to extract bugs from tree holes.

Innovation might have helped finches survive on the isolated islands, where they faced new foods and harsher conditions than on the mainland, Hendry says. "They are in an environment that probably favours innovation and novelty and just general intelligence," he says.

It's not yet clear if the insect repellent is a recently developed response to parasites or something the birds have done for a long time. *Philornis downsi* was introduced accidentally in the 1960s and its negative impact on finches was first noticed in the 1990s.

"That would be a really rapid and novel evolutionary response to a new selective pressure that was brought about by humans," Hendry says. "That would be pretty darn cool." ■

Cosmic knots inflated the universe

TAKE a good look the next time your headphone cable ends up in a tangled mess. The ballooning of the cosmos might be down to knottiness.

The universe is thought to have expanded rapidly just a fraction of a second after the big bang, undergoing a period of what's called inflation – or so the theory goes. It's still not clear what could have provided the energy to drive inflation, and observational evidence for this growth spurt has been inconclusive.

Now Arjun Berera of the University of Edinburgh, UK, and his colleagues have come up with a model that explains both inflation and why the universe has three spatial dimensions (see also page 30).

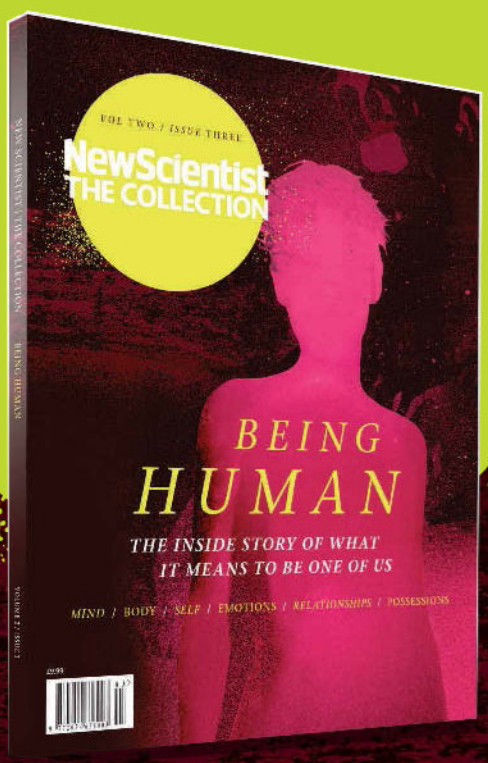
According to their theory, the early cosmos was flooded with particles resembling gluons – the force-carriers that stick quarks together to form protons and neutrons. As the universe cooled, stringy objects called flux tubes formed between the particles.

The tubes are a bit like the field lines you see when scattering iron filings around a magnet, but they are so densely packed that, like any kind of string, they become knotted. "If you take your headphones and put them in your backpack, they tend to get tangled," says Berera. "That's exactly the picture we're describing."

The network of entangled flux tubes contains a lot of energy – enough to drive inflation (arxiv.org/abs/1508.01458).

Knots can only form in three dimensions – add more, and the loops can pass through the extra dimensions and unlink. So Berera's proposal could explain the three dimensions we see: they were needed for the flux-tube network to form.

"I think it's an idea that's worth exploring," says Alan Guth at the Massachusetts Institute of Technology, one of the founders of inflation theory. But Berera's team has yet to make testable predictions, so it's still early days. Jacob Aron ■



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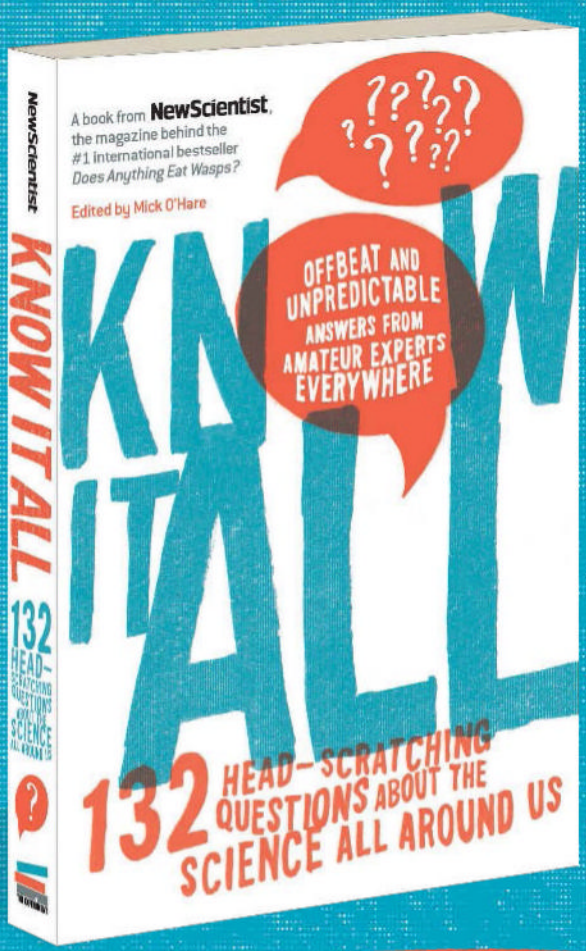

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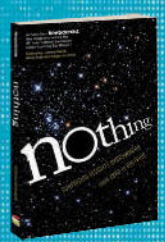

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JOEL JORGENSEN/NEBRASKA GAME AND PARKS COMMISSION

How do birds fly in dense fog? Very badly indeed

FOG can ground birds – but not always. One November morning in the Horicon wildlife refuge in Wisconsin, heavy fog settled. A group of sandhill cranes still set off from their roost to reach foraging areas despite the fog, providing a rare opportunity to study how the birds fly when visibility is very low.

Eileen Kirsch of the US Geological Survey's Upper Midwest Environmental Sciences Center in La Crosse and her team recorded the event and saw the cranes flying cautiously, staying close to the roost. The birds went in circles rather than straight lines. "They were going every which direction, which we've never seen before," says Kirsch. She thinks they were reluctant to fly further than they could see and were also trying to keep the flock together (*The Wilson Journal of Ornithology*, doi.org/65g).

The cranes also called more frequently and loudly than normal. This is common among birds flying in low-visibility conditions, says Graham Martin at the University of Birmingham, UK. It probably allows them to stay in touch. Usually, though, when there is fog, mist or heavy rain, large birds such as cranes, duck and geese stay put until conditions improve. "They can afford not to venture to foraging grounds for a couple of days," says Martin.

Kirsch thinks hunger and their impending southern migration made the cranes fly, despite the poor visibility. "It was very cold, and they needed to eat," she says.

Winking exoplanets hint at comet strikes

A WINK'S as good as a nod to an astronomer. Seeing an exoplanet suddenly brighten might hint that something has crashed into it. Information from that event could tell us a lot about the planet and its neighbours.

Current telescopes aren't sensitive enough to pick up light from an exo-Jupiter, but the next generation might be. To figure out how to tell if a comet has struck one, Laura Flagg of Northern Arizona University looked to comet Shoemaker-Levy 9, which slammed into Jupiter in 1994.

"I always imagine it as a splash," she says. "The comet broke up into much smaller pieces, and the particles settled in the stratosphere."

Flagg's analysis shows that Jupiter, if seen as a point of light in another solar system, would register only a small change in the months following the crash. But at near-infrared wavelengths where methane typically absorbs starlight, the planet could get twice as bright, since shinier dust debris would cloak methane's spectral signature (*Icarus*, doi.org/65v).

If a future telescope sees a quick brightening, it could tell us about the planet's atmosphere, and whether the system had comets, asteroids or another planet causing these objects to collide.

Mend a broken heart with Velcro

IT'S not just for shoes. A technique inspired by Velcro can bind strips of cells together into complex tissues that could be turned into living bandages for the heart.

To do this, heart cells are grown on meshes with tiny holes and hooks. Put the meshes in contact and they snag on to each other, so that tissue can be built up layer by layer. Over time, the mesh breaks down, leaving just the cells.

The developers of this Tissue-Velcro were able to create clumps of heart muscle that beat together in harmony (*Science Advances*, DOI: 10.1126/sciadv.1500423).

This technique could be used to make patches for repairing the damage caused by heart attacks, or to repair wounds more seamlessly. "Each case a surgeon is presented with is unique," says team member Miles Montgomery at the University of Toronto, Canada. "You could build this almost like designer tissue."

Break-ups give life rocky start it needs

ENDINGS are also beginnings. The break-up of continents may have allowed life to emerge on Earth.

Frieder Klein of the Woods Hole Oceanographic Institution in Massachusetts and his team found fossilised microbes in rock 760 metres below the sea floor off Portugal, dating back to when the supercontinent Pangaea broke up 125 million years ago.

Pangaea's break-up allowed mixing of ocean water and hydrothermal fluids beneath the sea floor, creating conditions that can support life (*PNAS*, DOI: 10.1073/pnas.1504674112).

The same conditions would have existed on Earth as far back as the origins of life, and may exist elsewhere in solar system, such as on Jupiter's moon Europa.

Mystery of insects that roar like lions

THEY are rather tiny to be kings of the jungle. Two species of mirid bug make sounds similar to the roars of big cats. Calls like these have never been detected before among insects, and we're not sure how the bugs make them.

The roars are too weak for our ears to pick them up, but they do cause minute vibrations in leaves where the bugs live. Valerio Mazzoni of the Edmund Mach Foundation in San Michele all'Adige, Italy, and his team exploited that to make them audible using a laser vibrometer, which detects and amplifies the leaf vibrations. "When you listen to these sounds through headphones, you'd think you were next to a tiger or lion," says Mazzoni.

If two males were put on the same leaf, a competitive roaring duet would follow. When one insect heard the other roar, it always followed suit. This suggests that, as in big cats, the calls might serve to establish dominance or attract females. Female mirids do not roar (*Journal of Insect Behavior*, doi.org/65h).

Curiously, mirid bugs only roar while walking. And unlike crickets, they make their calls without visibly vibrating or rubbing any part of their body. "It must be a specific organ in the abdomen producing the roars," Mazzoni says. He has yet to find anything that fits the bill.

NIGEL CATTLIN/ALAMY

Poison cannibal toads with their own eggicide

HOISTED by their own petard? Cane toad tadpoles produce chemicals that kill eggs of their own species, and that could give us a new way to clear the toad pest from Australia's ponds.

The toads have colonised all of north-eastern Australia since their introduction in the 1930s to help control an insect pest. Since then they've cut a swathe through predators – including crocodiles and marsupials – that eat them and die from their hallucinogenic poison, even causing local extinctions.

In 2010, Rick Shine from the University of Sydney in Australia showed that toad tadpoles eat eggs of their own species. Traps baited with eggs were set to catch tadpoles so they could be removed.

Now Shine has shown that tadpoles don't just eat eggs, but also make a chemical that kills them – presumably to reduce competition. In the lab, 95 per cent of eggs died when placed in water containing other tadpoles (*Journal of Applied Ecology*, doi.org/635).

This suggests that the caught tadpoles should be left in the water so their secretions continue to kill nearby eggs.

The next step is to conduct field trials, says Shine. He also wants to work out what the chemical is, and see if it can be used directly.

"If the collateral impacts are minimal, and we'd have to check that carefully, we could potentially deploy it prior to the toad breeding season," he says. "If we can construct a slow-release form, it could be a powerful weapon against the toad."

Happy days make you smarter

CHEER up, it might make you cleverer. We all have days when our brain goes at a snail's pace, and IQ really does fluctuate. If we're healthy, what's going on?

Sophie von Stumm at Goldsmiths, University of London, wondered if mood could be the brain's dimmer switch. "On bad mood days, we tend to feel that our brains are lame and work is particularly challenging," she said. "But scientists still don't really know if our brains work better when we are happy."

Over five days, her team asked 98 volunteers to assess their mood and tested their short-term memory, working memory and processing speed.

Bad mood didn't correlate with worse cognitive performance. But when people reported feeling positive, von Stumm saw a modest boost in their processing speed. It could be that the impact of a bad mood failed to show up because its effects are only seen at the extremes – a minor funk may not be sufficient, she says.

Her team have just launched an app called moo-Q to test the links between mood and IQ outside the lab, which more than 11,000 people have downloaded so far.

HENRIK WEIS/CULTURA/PLAINPICTURE

She ain't heavy, she's my sister

EVER argued with your little sister? Now you can blame her for your weight problems too.

Birth order is linked to a variety of outcomes later in life – firstborn kids are often taller and have a higher IQ, for example. But they are also more allergy-prone and now, it seems, fatter. A study of more than 13,000 pairs of sisters in Sweden found that although eldest girls are born slightly lighter than their younger sisters, they are about 30 per cent more likely to be overweight by their mid-twenties (*Journal of Epidemiology and Community Health*, doi.org/65j). The findings back up earlier work in men.

Co-author Wayne Cutfield from the University of Auckland, New Zealand, thinks the effect could be down to a first-time mum's inexperienced uterus. Blood vessels that nourish the fetus seem to be slightly thinner in first pregnancies, causing firstborns to be lighter and then overcompensate by eating more.

Gary Sacks of Deakin University in Melbourne, Australia, suspects social factors too. Maybe firstborns compete harder for food or get more money spent on them, he says.

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Body-hack with a zap

Electrodes could one day control our muscles to help us learn. **Hal Hodson** got himself hooked up

MY OPPONENT bobs and weaves in front of me, fists cocked, ready to attack. Gingerly, I settle into my own stance and prepare to fight. He closes in straight away and throws a few jabs, testing my guard. My forearm jerks back as his fist connects. Feeling my arm physically move is strange, because this boxing match is happening in virtual reality.

I'm experiencing this mash-up of real and virtual in the Hasso Plattner Institute, southwest of Berlin, Germany. This lab, run by Patrick Baudisch, is where the future of our interaction with computers is playing out. I felt the virtual punch because my arm is wired to an electrical circuit that fires in sync with the virtual world. The electricity stimulates the muscle into involuntary contraction, simulating the force of a landing punch.

"They wrote code to jolt their arms to perform a plant-watering motion, as a reminder"

Pedro Lopes is investigating this phenomenon, known as electrical muscle stimulation (EMS), as a channel by which computers and brains could communicate. By talking directly to the nervous system through our muscles, Lopes and other researchers like him can guide a person's body movements, providing a novel way to interact with technology.

Electricity is already being used to control the body in medical applications. For example, pacemakers help to regulate the heartbeat by delivering timed electrical pulses. Lopes and Pfeiffer want to bring this mode of interaction to consumer technology, although without the implants for now, and on less crucial muscles than the heart.

Lopes keeps electrodes on his forearm all day while he's working in the lab. Wires dangle loose as he explains his work. He has made EMS a part of his life. He and a student kept forgetting to water the plants, so they wrote code that would jolt their arms to perform a watering motion periodically, as a reminder. It worked for a while, but now the plants sit brown and dry on Pedro's windowsill. Outside, a robot lawnmower with a plastic sheep attached to the top whirs by.

A diagram of the muscles in the human hand hangs above Lopes's head. His most sophisticated system, called Affordance++, can control a number of these using electricity, guiding hands to operate a drill or play an instrument, for instance. Another, called Pose IO, tweaks arm muscles to change the position of the limb and relay information.

Max Pfeiffer, who is also working on EMS at the University of Hannover in Germany, thinks of it as a supporting technology that simplifies the way we interact with our devices so we waste less time. He is using electrical stimulation to guide a person's legs along a predefined path. "For instance, I hate when I'm running around and need to look at my map. My purpose is to go there, help me do that," he says.

EMS's first application as a computer conduit is likely to be in virtual reality, helping to heighten the immersion of a simulation by moving the body in conjunction with other stimuli. Making me feel like I got punched is a good start.

"Someone hitting you turns out to be really hard to simulate," Lopes says. The sensation is split into multiple parts. First, a small plastic arm just barely touches me, then the electrode provides a little jolt of electricity – "but put

ELECTRIC THREADS

Stimulating our muscles with electricity could provide a novel interface between us and our computers. However, getting electricity into muscles non-invasively poses a challenge (see main story). Help may be at hand.

Google's Project Jacquard aims to weave electronics into the fabric of normal clothes, working with clothing brands to embed circuitry early in the manufacturing process. "LEDs, haptics and other embedded outputs provide feedback to the user, seamlessly connecting them to the digital world," explains Google's page on the project.

Future interfaces may even stick to our skin. John Rogers's lab at the University of Illinois has developed thin, stretchable electronic films that can be worn for days at a time and communicate with other devices wirelessly. The films are light enough to stick to the skin with Van der Waals force and could deliver electricity to muscles, with batteries and microprocessors built in.

PEDRO LOPES

A bit less virtual, a bit more reality

the two together and your brain gets a little bit tricked. It feels like, in VR, that this boxer was hitting you," says Lopes.

Uncanny valley

But EMS faces a substantial obstacle: it feels really weird to have a computer take control of your muscles. At one point, Lopes wires up my forearms and sits me down in front of a can of spray paint. He asks me to pick it up, then taps a few commands into his computer. My hand gets the unmistakeable instruction to shake the can, and my muscles obey.

It is possible to resist the electric commands. I hold my hands stiff as Lopes shocks me again, and am able to keep dead steady. "I could go to a level where that fight gets more complicated, where you would have to push even more," he says. "The opposing muscle would have to be really strong."

This willing handover of control might prove too much for EMS to really take off as a mainstream technology, while the electrical sensation takes a while to get used to. But tweaks such as custom electrodes could soften the "zappy" feeling, says Pfeiffer, which might help reduce the weirdness.

Zappy feeling

Using implants would give finer control over the EMS sensations. Lopes is already talking to a group from the Max Planck Institute in Germany who are making implants out of thin metal hairs. These reach through the skin into different layers of muscle in the arm and can fire at different depths, offering high-precision control of specific muscles. The implants are designed to help those with motor neuron disease, but Lopes says the Max Planck group is casting around for other applications too.

He views these kinds of implants as inevitable, even if they don't become mainstream for many years. If and when they do, the fine-grained muscle control they offer could let those with the skills for a specific task, say soldering, take control of the arms of those who don't know how.

Pfeiffer sees applications in sports, with electrodes guiding athletes' muscles during training, allowing them to focus on the higher-level mental challenges of a certain move or play. "If you're in training and the coach wants to train a specific running pattern" they would simply draw it on a tablet and have their players guided through the move, he says.

"The canonical way of learning a new skill is YouTube tutorials," says Lopes. "My vision was that instead of watching a video, a tutorial would play EMS, designed by someone to teach you." ■

Crowdsourcing song site lets you vote for a note

EVER fancied yourself as the next Paul McCartney? Now's your chance to practise, with a website that brings strangers together to write a song.

CrowdSound is the brainchild of Brendon Ferris, a programmer living in the Dominican Republic. Ferris was inspired by the teamwork on Wikipedia and reddit, the news site where users decide which posts and comments deserve prominence.

"My way of thinking was, if the crowd decides what the next note is, then there must be something there that appeals to the most people," says Ferris. "The song should sound good to everybody."

On CrowdSound, the song builds up one note at a time, guided by a chord structure set by Ferris.

Visitors listen to what has been written so far and are then offered a choice of what to add next: one of a selection of musical notes or a beat's rest. After 50 votes, the most popular selection is added to the song and the cycle starts again.

Crowdsourcing has already found some success in the music world, though usually with an expert overseeing the final product.

In 2013, Swedish DJ Avicii invited people to submit and vote on sounds, with the top choices finding their way into the song *X You*. American composer Eric Whitacre has curated videos of various unrelated singers to create a "virtual choir".

In Detroit, Michigan, the city orchestra has teamed up with MIT composer Tod Machover to build a collaborative symphony, inviting residents to contribute locally found noises such as car horns and soda cans. The finished work is due to premiere in November.

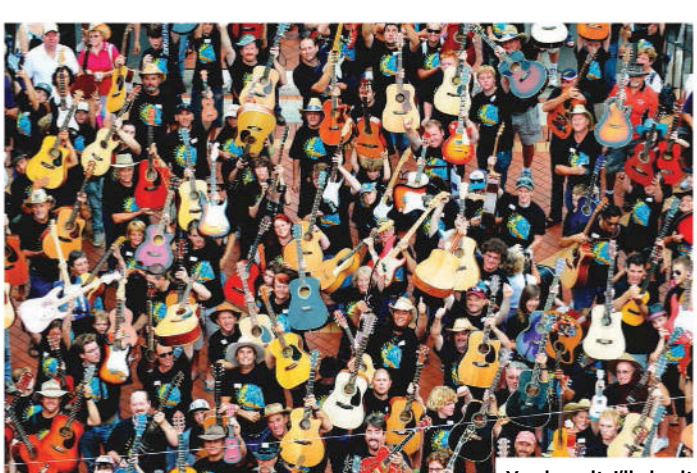
Ferris is happy with how the CrowdSound song sounds so far. "It's exceeded my expectations," he says. David Cope, a former composer at the University of California, Santa Cruz, has visited the site and voted on a note. He thinks the idea has potential – but fears the finished song could end up a little boring.

> "If the crowd decides the next note, there must be something there that appeals to most people"

"We all tend to have at least slightly different tastes," says Cope.

"Probabilistically finding an average best choice will, by definition, produce a statistically average output."

You can listen to the song so far – and vote on the next note – at crowdsound.net. Aviva Rutkin ■



TRACEY NEARMY/CORBIS

You hum it, I'll play it

Watching with intent

Surveillance only when it matters is a smart step, says **Aviva Rutkin**

IT WAS being in London that got Victor Bahl started. The UK is awash with millions of closed-circuit TV cameras, and as Bahl walked around the city, he realised that much of what the cameras record would never be of interest to anyone.

"I thought, hey, there's so much video streaming that no one's looking at," says Bahl, who is based at Microsoft Research in Redmond, Washington. Resources are being squandered all the time, on installing ubiquitous cameras to record stuff that isn't worth keeping. "We simply don't have the ability to process all those images," says Paul Schrater at the University of Minnesota in Minneapolis.

Bahl's trip provided the inspiration for Vigil, an intelligent camera system to be presented next week at the International Conference on Mobile Computing and Networking in Paris.

Before anyone sees its footage, Vigil looks at every frame, counting the number of objects that might be noteworthy, such as people or car licence plates. Only then does it upload snippets of video, ranked from most to least important, to the cloud.

For the last two months, the Vigil team has had the system running at three sites, surveying labs or office hallways in London, Redmond and Madison, Wisconsin. Next year they hope to launch a bigger pilot, perhaps monitoring traffic on a city road.

Bahl imagines that a system like Vigil could one day be used to detect the most exciting spots on the field during football games, switching TV coverage there automatically. It could also tell store managers when customers pick up certain products from their shelves.

Butterfleye, a start-up in San Francisco, is crowdfunding a smart camera to keep tabs on homes when the occupants are away. It starts recording whenever it detects movements or sounds, then notifies the user with a link to the live feed and a note describing what it has seen: "Today, Butterfleye saw a person at 8.45 am", for example.

"It counts noteworthy objects like people or car licence plates, then ranks video clips accordingly"

Smart cameras aren't just useful for surveillance. At iniLabs in Zurich, Switzerland, engineers have used IBM's TrueNorth chip – designed to mimic neurons at work in the brain – to power a vision sensor that behaves like the human retina, responding only to changes in light levels.

Kynan Eng, a co-founder of iniLabs, says the technology is far more efficient because image processing only kicks in when something interesting happens. That makes it useful for long-running research experiments or power-hungry devices.

And another device about to launch, Vidalife, is designed to capture memorable moments around the home. When it senses a human interaction happening before the camera, it makes a recording and saves it for posterity. "Every camera deserves to be a smart camera," says Raji Kannan, co-founder of LensBricks, the California-based start-up behind Vidalife. ■

DAVID MALAN/OCEAN/CORBIS

Lights, camera... oh never mind

ONE PER CENT

JOCHEN TACK/ALAMY

We cover potholes, too

So long, bumpy roads! Google has patented a system, built into a car, to detect jolts from potholes. It relays the potholes' GPS location back to Google, allowing it to build a database of road quality and route cars away from bad roads. Some cities already have similar projects that rely on smartphone apps, but Google, which may soon have fleets of self-driving cars, may do a better job.

1 billion

The number of people who used Facebook on 24 August. With one-seventh of the world logging in, according to founder Mark Zuckerberg, it marked a new milestone for the social network.

M, find me a tapas bar

Facebook's AI can now book you a restaurant table or buy flowers for your mum. Last week the social network launched a trial version of M, a personal assistant which works through the company's messaging system. Users can chat to M to get it to complete tasks for them. Human workers will supervise and handle difficult questions for M, and their answers will be used to train and improve the AI.

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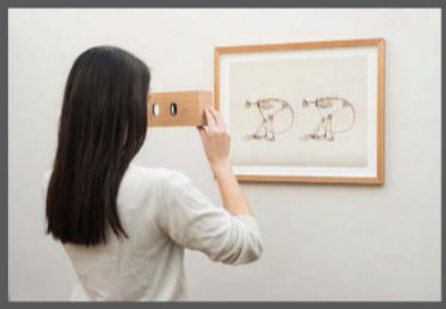
Gibbon in stereo

These photos of a lar gibbon skeleton were taken at London's Grant Museum of Zoology – from locations 6.4 centimetres apart. Go cross-eyed until the images overlap, and they may fuse, allowing you to see the gibbon in 3D. You may also feel that the skeleton is moving: the ribcage seems to belly out, the stance becomes lifelike. You might even get the sense that you are looking out of someone else's eyes – unless your eyes are exactly 6.4 centimetres apart, that is.

This sense of presence, of witnessing a moment, appeals to artist Jim Naughten, whose "stereograms" portray animals preserved by Victorian collectors. "The effect of looking at a stereoscopic image is magical and transformative," he says. "There's a strong sense of being present in the past" – appropriate enough for a technology as old as photography itself.

For those who struggle to fuse the images, help is at hand. Visitors to Naughten's show Animal Kingdoms, at the Horniman Museum in London from 26 September, and later in the year at the Klompching Gallery in New York, will be handed special stereoscopic viewers (below). A book of images, complete with stereoscopic glasses, is in production. Simon Ings



Photographer
Jim Naughten
jimnaughten.com

Trial by repetition

Invasive species are often fingered as the bad guys when other species die out. How did that idea get so popular, asks **Fred Pearce**

SOME "facts" are just too good to check. You might hope science would be immune from this sort of pitfall, but it seems not.

In much of ecology, it is taken as read that invasive species were a major culprit in recent extinctions. This is widely stated, despite a lack of evidence for it. While doing research for my latest book, I found the claim being passed on in ways reminiscent of Chinese whispers.

The UK government's Non-native Species Secretariat (NNSS) declares that invasive species have "contributed to 40 per cent of the animal extinctions that have occurred in the last 400 years". Its source is the *Global Biodiversity Outlook 2* report, published in 2006 by the secretariat of the UN Convention on Biological Diversity (CBD).

They, in turn, say the stat came from a 2005 paper by Cornell ecologist David Pimentel, who

was in turn drawing on a 1998 paper by David Wilcove, now at Princeton University.

As is clear from the paper's title, "Quantifying threats to imperiled species in the US", Wilcove was not talking about actual extinctions but an extinction threat, and in the context of the US (in fact, his data largely related to Hawaii). Wilcove told me his paper was being misused. Although informed of this, the NNSS has kept the claim on its website.

The claim is absent from the most recent *Global Biodiversity Outlook* report, issued last year, but has been replaced with: "Species introduced into new environments… have contributed to more than half of the animal extinctions for which the cause is known."

The report cites a 2005 paper in the journal *Trends in Ecology & Evolution*, by Miguel Clavero and

Secrets, lies and DNA

Should family get to see a loved one's genomic data after death, asks **Annelien Bredenoord**

WITH DNA sequencing becoming faster, more accurate and cheaper, medicine is in the midst of a genomic revolution. Many more people are likely to have their genome mapped in coming years.

While alive, some individuals will choose not to share genetic information with their family. This could be for reasons of privacy, or perhaps because of a rift or doubts about their parentage. That means details of serious heritable diseases won't always be passed on.

But when the person dies, a new dilemma arises. Is confidentiality still sacrosanct, or should close relatives be told about or given access to the deceased's genomic data? This question has no clear answer yet. It's high time it did.

There are many arguments for opening up the data to relatives. Doctors arguably have a duty to warn of any hereditary disease risk, especially if it poses an imminent risk of harm.

Then there's the idea that genomic data can help relatives plan their lives – for example, in making choices about having children. Finally, some would argue that a genome is, by its very nature, family property.

"Access to a close relative's genome once they die could lead to psychological, social or financial harm"

There are also many arguments against. Relatives may not want to know about their risk of inherited disease. Access to the data could lead to psychological, social or financial harm. Some say a patient's desire for confidentiality should extend beyond death. Finally, to inform and counsel all relatives may be unfeasible.

My colleagues and I think the default should be passive disclosure: allowing clinicians to pass on data after a death, if relatives ask for it. In the event of a health risk that is imminent and serious but also treatable, active disclosure should be

Emili Garcia-Berthou of the University of Girona, Spain. But that turns out to be just four paragraphs long.

It reports, but gives no details of, an analysis of a quarter of the 680 extinct species in an International Union for Conservation of Nature (IUCN) database. The authors told me they had not kept the details of their analysis, nor notes on which species they had included.

This work was a riposte to a rather longer paper by Jessica Gurevitch and Dianna Padilla of Stony Brook University in New York, who looked at the same IUCN database and concluded that just 2 per cent of all extinctions had alien species listed as a cause.

I could go on. Suffice it to say that Gurevitch and Padilla may have been on to something when they concluded that "available data supporting invasion as a cause of extinctions are, in many cases, anecdotal, speculative and based upon limited observation".

It seems that even in science, sometimes the facts aren't allowed to get in the way of a good story. ■

Fred Pearce is a consultant for *New Scientist* and the author of *The New Wild: Why alien species will be nature's salvation*

considered, with clinicians taking the initiative to reveal the data.

Anyone having genomic sequencing now should be counselled on family impact, and, if need be, an agreement should be drawn up about passing data on after death.

The rise of genomics requires that professional and regulatory bodies get to grips with these matters now. ■

Annelien Bredenoord is a biomedical ethicist at the University Medical Center Utrecht, the Netherlands. She co-authored a recent paper on this issue (*Trends in Molecular Medicine*, vol 21, p 148)

ONE MINUTE INTERVIEW

Slaves to the rhythm

Our body clock's daily fluctuations mean we present a moving target for drugs, warns chronobiologist **John Hogenesch**

TOMMY LEONARDI

PROFILE

John Hogenesch is a chronobiologist and a professor of pharmacology at the University of Pennsylvania in Philadelphia. Last year he published an atlas of "circadian gene expression" in mammals (*PNAS*, doi.org/634)

What is a body clock?

The circadian clock is a molecular clock that is probably found in every body cell. However, the master clock that orchestrates all of our biological rhythms is in a region of the brain called the suprachiasmatic nucleus. This helps to synchronise the body's other clocks.

Why is it important to understand our circadian system?

A great deal, if not all, of our physiology is influenced by these clocks. One of my team's goals was to find out how they affect gene expression to influence things such as fluctuations in blood pressure and hormonal rhythms. We were able to pick out genes that were under circadian control by monitoring the proteins expressed in the organs of mice at 2-hour intervals throughout the day. About half of these genes were clock-regulated.

How can we make use of this information?

We can predict which drugs may work better when taken at certain times of day and when to take them. If a drug only stays in the body for a few hours, it needs to be taken when the protein it targets is being expressed by the relevant gene, otherwise it won't have a target to hit. We've discovered that 56 of the 100 bestselling drugs in the US, and a similar proportion of the World Health Organization's essential medicines – drugs that are supposed to be in every hospital in the world – actually hit clock-regulated targets. So they will be more, or less, effective depending on when they are taken.

Can you give an example of a drug that works better at specific times?

Valsartan is a drug given for high blood pressure. If people take it before bedtime, it is about 60 per cent better at controlling arterial pressure than if they take it after waking up. Doctors don't tell people this. And our research predicts that some drugs will work best in the middle of the night. It's unlikely that somebody is going to wake up at 3 am to take a drug, of course, but delayed-release formulations could be developed that can be taken before bed and which switch on later.

How do you think we can use this knowledge of our daily variability?

Among many things, the body clock regulates our sleep-wake cycles – some of us are morning people, whereas others are night owls. I'd like to take this variation in "chronotype" into account in the timing of drug administration. This isn't far-fetched. You can already use wearable tech such as Fitbits or your smartphone to monitor when you are active and inactive, and therefore when some of your genes might be more or less active. Using this information, a device could alert you about when to take a particular drug.

How do you see the future shaping up?

Thirty years down the road, I think it would be awesome if we had drugs that you simply take in the morning and they activate themselves whenever the body is most responsive to them.

Interview by Linda Geddes

Give the gift of sight – and insight will follow

Restoring the sight of blind children can illuminate how we piece together the visual world, says **Pawan Sinha**

What fascinates you about vision?
My fascination stems from my interest in art. As I made drawings as a kid, there was always a question in my mind: what can I put on this piece of paper that allows me to convey the identity of a face or an object to the viewer? It is very close to the question a vision researcher would ask: what information does the brain need to discern what it is seeing in the world?

How did you go about finding out?
I founded Project Prakash, a service in India that helps to restore children's sight. There are many children in India who are blinded by cataracts – which can be caused by rubella during the mother's pregnancy – or other treatable conditions. Restoring their sight also provides a research platform to learn more about the visual system.

What have you learned from the project?
Scientifically, the key message is that the brain remains significantly plastic well into late childhood and even early adulthood. It also raises many questions about how and when different visual abilities develop. But the most wonderful lesson has been a personal one. I've gained a new appreciation for just how little it takes to transform a person's life – a few hundred dollars and a little effort to identify the children we can help with treatment. Very often one has the feeling that the best we can do is try to live a good life. Project Prakash has shown me is that there are opportunities to make tremendous differences even as you pursue your professional goals.

How do the children react to restored vision?
When a child sees the world for the very first time, one might imagine it's like the movies, with the child jumping up and down, happily yelling, "Yes, I see this! I see that!" But that's not what happens. Once we remove the bandages, there is a very subdued reaction in those first moments. The child is seeing, yes, but it's a confusing mess of information. Then over a few days there is an amazing transformation. The child becomes more confident in their use of vision: they start to rely on it. By the time that child is ready to head home, you will see them walking completely unaided along the hospital corridors, sometimes running. Something is changing rapidly in those first weeks.

How do they make sense of what they're seeing?
We've learned that motion information is a powerful force. As these children see how things move in the world, it provides the brain with a tremendous amount of information about how to distinguish objects, backgrounds, foregrounds and so on. Dynamic information is a powerful cue for visual learning – and may be the fundamental process that helps the brain make sense of a very complex world.

"Newly sighted children tend to see images as comprising many small pieces"

You've suggested the importance of dynamic information goes beyond vision. Tell us more.
This was an unexpected but gratifying outcome of Project Prakash: the idea that problems in processing dynamic visual information may play a role in autism. Children with autism have normal vision in terms of acuity, sensitivity to contrast and colours, but they have problems integrating information across different senses. Your perception of the world is made up not only of the things you see, but also the things you hear, feel and smell. If they don't seem to fit together, that is a very difficult experience.

When we were working with the Prakash children, we saw something similar in the first few months after the restoration of their sight – they had integration problems.

Give us an example of an integration problem.
When viewing images, newly sighted children tend to "over-fragment" them: they see them as comprising many small pieces. Almost every region of a different colour or brightness is seen as a separate entity and it is difficult for the children to integrate them and perceive the image as a whole. I thought it might be a superficial similarity to what happens in autism, but I couldn't help thinking that dynamic information was the key. If that is what helps formerly blind children understand how to integrate sensory information, then perhaps there is something impaired in the dynamic-information processing systems in children with autism that interferes with them making sense of their world.

So you then worked with children with autism?
Yes, and we found that their ability to anticipate what's going to happen next in a dynamic

PROFILE
Pawan Sinha explores vision and computational neuroscience at the Massachusetts Institute of Technology. He founded projectprakash.org in 2005 to treat blind children in India and investigate how the brain makes sense of sight

Photographed for New Scientist by Ken Richardson

Understanding movement may help the brain process colours and shapes

sequence – such as the trajectory of a thrown ball – is indeed impaired. This skill is very important. When you interact with a dynamic world, you need to know more than just what's happening at a given moment – you need to anticipate how it might change in the next moment so you can take the right actions. We proposed a new theory of autism, called the predictive impairment theory, or the magical world theory. Our hypothesis is that people with autism may have a reduced ability to predict what will happen next, making the world feel chaotic and overwhelming.

Your work also addresses long-running questions on how visual illusions work. How?
The dominant belief has been that there is a long learning process that helps us understand perspective cues, such as converging lines typically corresponding to depth. So when we see certain illusory images, our brains can't help but tap into that learning to make inferences about what we're seeing. If that's the case, a newly sighted child should not fall prey to such illusions. But, to our surprise, we found that on the very first day of bandage opening, Prakash kids did see the illusion. That suggests that no learning process is required, but rather it's something in the hardware of the visual system that predisposes us to these illusions.

What are the challenges of merging science with service in Project Prakash?
Perhaps the greatest challenge is finding children in need of care, as they typically live in remote areas. Their parents have no idea their condition is treatable. In fact, when the parents talk to village elders or the village priest about the problem, they are told that the child's blindness is due to a bad deed in a previous life. That dampens their enthusiasm to seek treatment. That makes it imperative for us to go out into the villages, conduct screening camps and identify children, instead of waiting for them to show up at the hospital.

When will your mission be fulfilled?
Not in my lifetime, because the idea of merging healthcare with scientific research can be applied so widely. After the original Prakash team is gone, and the project is on an even stronger footing and expanding to help kids with other conditions, such as cerebral palsy, we will be fulfilling our mission. ■

Interview by Kayt Sukel

WHAT CAME BEFORE THE *BIG BANG?* AND OTHER QUESTIONS PHYSICS CAN'T ANSWER... YET

Physicists ponder some of the deepest questions in nature, from the origins of the universe to the mysteries of matter. But they are far from having all the answers.

From why we travel forwards in time to how bicycles travel forwards at all, *New Scientist* presents the questions great and small that continue to stump our finest minds

MATTHEW RICHARDSON

WHAT CAME BEFORE THE BIG BANG?

PAUSE. Rewind. Suddenly the outward rush of 200 billion galaxies slips into reverse. Instead of expanding at pace, the universe is now imploding like a deflating balloon: faster and faster, smaller and smaller, everything hurtling together until the entire cosmos is squeezed into an inconceivably hot, dense pinprick. Then pshhht! The screen goes dead.

According to the big bang theory – our best explanation for why space is expanding – everything exploded from nothing about 13.8 billion years ago. Cosmologists have been able to wind things back to within a tiny fraction of a second of this moment. But now they're stuck.

The trouble is, our understanding of space-time, and gravity in particular, is built from Einstein's equations of general relativity, whereas the extreme conditions of the very early universe can only be described by quantum mechanics. No one knows how to reconcile the two to take us further back. "The rules we have simply don't work in that regime," says Carlo Contaldi at Imperial College London. "Nothing makes sense any more."

That's a problem for our origin story. Did time begin with the big bang? Or was there an epoch before it?

Some insist that if we rewind the universe far enough, time just stops. But Lee Smolin of the Perimeter Institute for Theoretical Physics in Waterloo, Canada, is having none of it.

"It's a cute idea but there's not much evidence for it," he says. In fact, Smolin wants to see the idea that the universe has a starting point dropped entirely. We can only hope to explain why our universe is the way it is, he says, if there was something before the big bang. It's about cause and effect; to arrive at satisfying explanations for why things are as they are, we draw on previous events that led to the conditions we see.

One possibility is that instead of a bang, there was a bounce. In this scenario, rewinding our universe would not take us back to a point containing infinite mass in an infinitely small space. Instead it would take us through the unimaginably hot, dense beginning of our universe and out the other side into the unimaginably hot, dense ending of a previous universe.

Acknowledging that something came before the big bang would open the door to explanations of how the universe came to be just right for life. Otherwise we either have to accept that our perfectly crafted universe was just a fluke or that it is one of an infinite number of universes, most of which look very different, and we only think of it as special because we're in it.

Or perhaps our bang was one of many. Some think our universe popped into existence as a bubble in a frothing sea of universes. This idea gives our universe a beginning but introduces an everlasting multiverse.

Can we ever really know? Smolin thinks we could soon see clues in the cosmic microwave background – radiation given off by the early universe. It's possible that ripples in space-time known as gravitational waves might also survive a bounce.

Contaldi is not holding his breath. We need a working theory of quantum gravity and a new understanding of time, he says. Without that, "I don't think we have the tools to even pose the question properly."

Douglas Heaven

HOW DO BICYCLES STAY UPRIGHT?

IN 2011, an international team of bi-pedal enthusiasts dropped the bombshell that, despite 150 years of analysis, no one knows how a bicycle stays upright. Across the world, riders dismounted and stared at their bikes in disbelief. What they had been doing for years was a feat inexplicable by science.

Well, sort of. "What we don't know are the simple, necessary or sufficient conditions for a bicycle to be self-stable," says Andy Ruina, an engineer at Cornell University in Ithaca, New York.

We have relied on trial-and-error engineering to construct stable bikes that aren't prone to toppling while in motion. Explaining how they work mathematically requires around 25 variables, such as the angle of the front forks relative to the road, weight distribution and wheel size.

Before 2011, researchers had reduced this profusion to two things. One was the size of the "trail", the distance between where the front wheel touches the road and where a straight line through the forks would meet the ground. The other was the gyroscopic restoring force that acts on a spinning wheel to keep it upright.

Ruina and his colleagues, including Arend Schwab of the Delft University of Technology in the Netherlands and Jim Papadopoulos of the University of Wisconsin-Stout at Menomonie, not only revisited this mathematics, but also skewed the trail and gyroscopic forces in prototype bikes to make them technically unrideable. To everyone's surprise, the bikes were still stable (*Science*, vol 332, p 339).

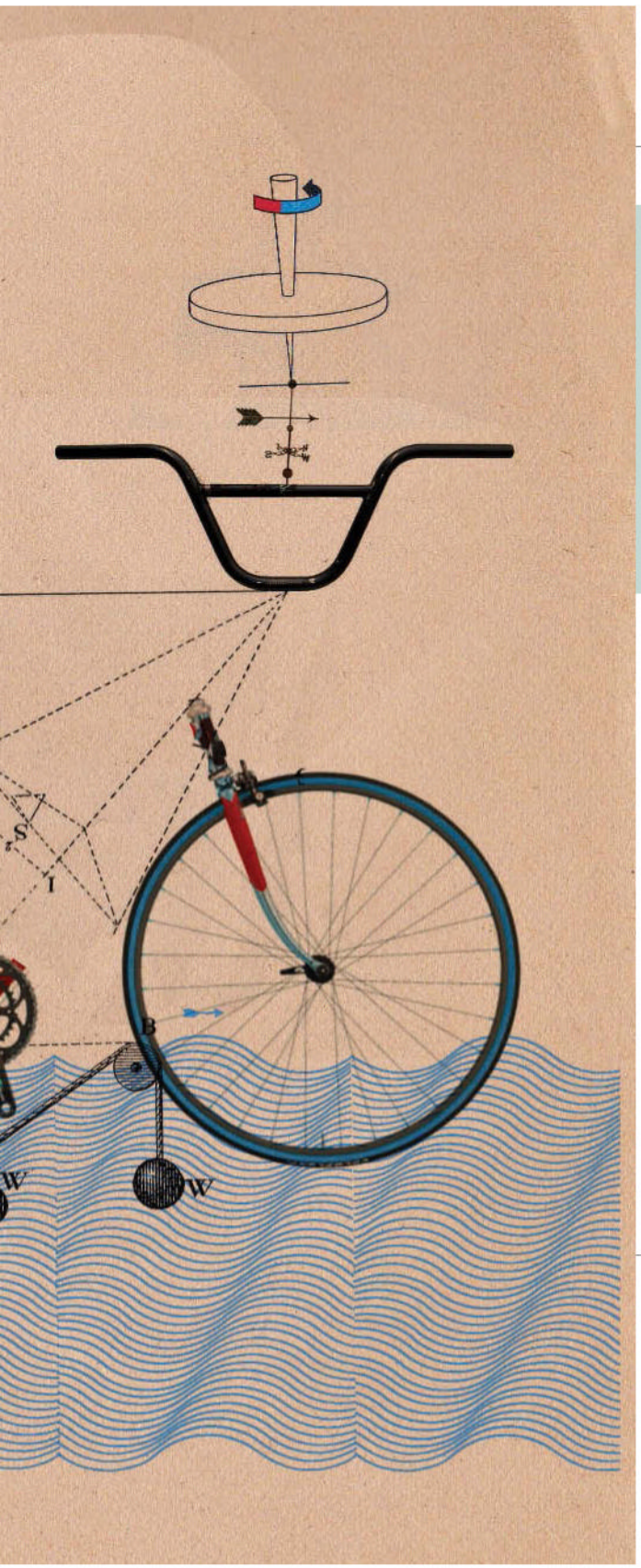
The researchers haven't been resting on their saddles since. Last year Ruina unveiled a "bricycle", a cross between a bicycle and a tricycle with spring-loaded stabilising wheels that can be adjusted to vary the rider's perception of contact with the ground. By studying the influence this has on how the rider steers and remains stable, he hopes to gain new insights that might lead to more easily controllable bicycles.

It's still an uphill struggle. "I think the real understanding of bikes requires a mix of what we did, plus some kind of brain science," says Papadopoulos. Human riders act in extremely complex yet intuitive ways to keep a bike balanced and on track. At very low speeds, for example, we recognise that the handlebars become useless for steering, and instead direct the bike by wobbling our knees.

Why? "We don't know," says Schwab. Yet another bike-based mystery that could be around long after we've worked out the origins of the universe.

Michael Brooks

MATTHEW RICHARDSON



WHERE DOES QUANTUM WEIRDNESS END?

"WE DO not find, at breakfast, that the milk is simultaneously poured onto our cornflakes and not," says Andrew Briggs, a physicist at the University of Oxford. Nor can you be in two places at the same time, no matter how hard you try. None of which is even remotely surprising. Until, that is, you consider that the laws of quantum mechanics insist that subatomic particles such as electrons routinely pull off such a feat.

So if electrons can pop up in multiple places at once, why can't milk and humans – essentially collections of fundamental particles – do the same?

Here we have to start small. This particular brand of quantum weirdness is best illustrated by the double-slit experiment, where you fire a beam of electrons, one after another, at a screen containing two slits. You would expect the electrons to pass through one slit and hit the detector placed behind the screen at a single point every time. But reality isn't always that straightforward.

When researchers don't keep track of each electron's path, the beam passes through both slits simultaneously in the same way as a light wave, creating a pattern of bright and dark stripes on the detector that is characteristic of two overlapping wavefronts. So electrons can exist as both waves and particles at the same time – a phenomenon known as wave-particle duality.

As if that wasn't weird enough, when researchers monitor one of the slits, the interference pattern disappears. Electrons suddenly abandon their wave-like behaviour, preferring to travel through one slit and produce a single spot on the detector.

Physicists explain this by invoking the wave function, a mathematical widget that describes the probability of finding a quantum object in a particular state or location at any given time. When the particle is measured or disturbed in some way, its wave function collapses and it snaps into a ›

single state and a definite position.

This collapse can be triggered by any interaction of a quantum object with its environment – a rogue vibration, for example, or a heat fluctuation. That leads us to an unsettling conclusion. Isolate a molecule even hundreds of thousands of times the size of an electron sufficiently from its environment,

"As Schrödinger said, it is absurd to say a cat can be both dead and alive at the same time"

and there's a chance it might still be existing in its uncollapsed quantum state. Indeed, researchers have now spotted improbably large objects – including tiny resonating strips of metal visible to the naked eye – existing in two states at once.

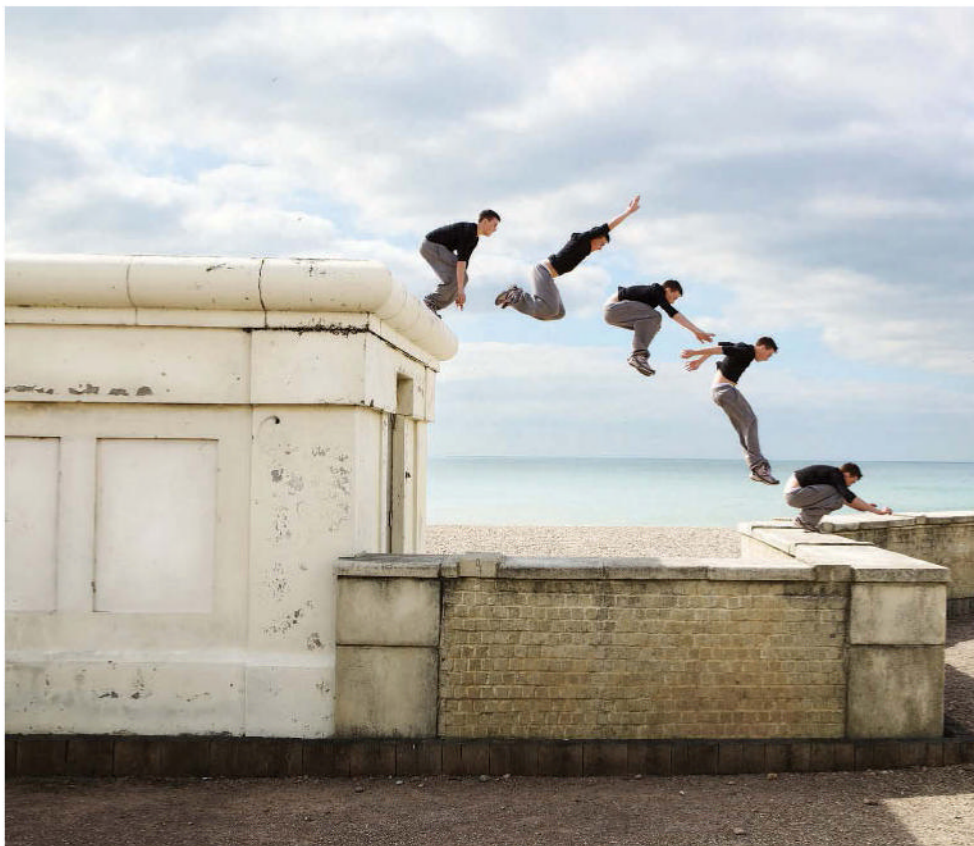
Even so, it's pretty clear that once something gets large enough, it throws off its quantum properties. As Erwin Schrödinger noted, it is absurd to say a cat can be both dead and alive. So how large can quantum weirdness go?

"Some physicists would say the size limit depends on the size of your chequebook," says Briggs. With a sufficiently sophisticated experiment, he argues, researchers could reliably screen out disturbances from the environment ever more finely to show ever larger objects obeying quantum rules. Together with colleagues at Oxford, Briggs is testing the limits of quantum behaviour more rigorously than any experiment to date. The challenge is to find ways to place bigger things in fuzzy quantum states that are less sensitive to outside influences.

But Briggs does not expect to solve the conundrum any time soon. That's partly down to the difficulty of defining a "system" in quantum mechanics. Strictly speaking, anyone or anything observing quantum interference becomes part of the system, making it tough to draw conclusions about the size at which quantum effects vanish.

"You can always argue that you, the observer, are in superposition too," says Briggs.

Joshua Howgego



GALLERY STOCK

WHY DO WE MOVE FORWARDS IN TIME?

THERE is a reason we say time goes by: it seems to flow. No matter how still we stand in space, we move inexorably through time, dragged as if in a current. As we do, events steadily pass from the future, via the present, to the past.

Isaac Newton saw this as a fundamental truth. "All motions may be accelerated and retarded, but the flowing of absolute time is not liable to any change," he wrote.

So how does time flow, and why always in the same direction? Many physicists will tell you that's a silly question. "The idea that time can in some meaningful sense be said to flow, it's just a complete non-starter," says Huw Price, a philosopher at the University of Cambridge.

For time to flow, it must do so at some speed. But speed is measured as a change over time. So how fast does time flow? George Ellis, a cosmologist from the University of Cape Town, South Africa, has an answer: "One second per second." Price says that's meaningless. Even if time were standing still, it could be said that for every second that passes, one second passes. Indeed, if that's a measure of flow, we could say that space flows: it passes at one metre per metre.

Ellis is up against one of the most successful theories in physics: special relativity. It revealed that there's no such thing as objective simultaneity. Although you might have seen three things happen in a particular order – A, then B, then C – someone moving at a different velocity could have seen it a different way – C, then B, then A. In other words, without simultaneity there is no way of specifying what

things happened "now". And if not "now", what is moving through time?

Rescuing an objective "now" is a daunting task. But Lee Smolin of the Perimeter Institute for Theoretical Physics in Waterloo, Canada, has given it a go by tweaking relativity. He argues that we can rewrite physics in a way that includes "now" if we sacrifice some of our objective notions of space.

Most physicists aren't having it. The general consensus is that time is more or less just like space – an immutable dimension, stretched out through a four-dimensional "block universe".

"Every moment in that universe has a past, present and future," says Sean Carroll from the California Institute of Technology in Pasadena. "A person is described as a history of moments, and those moments all have a feeling that they're moving from the past to the future."

That doesn't answer the question so much as shift it. If time does not flow, what makes us think it does?

Michael Slezak

WHY DOES SPACE HAVE THREE DIMENSIONS?

AH, BUT does it? For anyone versed in modern theoretical physics, that's not such a silly question. "I don't know any mathematical reason why three-dimensional space is more consistent than any other number," says Leonard Susskind of Stanford University in California.

Susskind is one of the founders of string theory, which is our best stab yet at a unified understanding of physics – and perhaps the best-known model in which extra dimensions are found. One of string theory's peculiar features is that when applied to fewer than nine spatial dimensions, the mathematics goes wild, predicting violent fluctuations that rip apart the very fabric of the universe.

But extra dimensions do more than just save string theory's blushes. In a wider set of theories, gravity leaking into a higher space could explain why in our three dimensions it is so weak compared with the other fundamental forces, and why the expansion of the universe is apparently accelerating.

So perhaps the question becomes: why does space have three *visible* dimensions?

One idea from string theory is that the universe started out as an infinitesimally small 9D ball of string, but only three strands unfurled in its subsequent headlong expansion, leaving the others tucked up tightly in every pixel of our 3D space. Or perhaps our 3D universe exists on one of many "branes", membrane-like entities that float around in a larger, higher-dimensional space.

Lisa Randall of Harvard University and Andreas Karch of the University of Washington in Seattle have shown that branes colliding in such a space would tend to form 3D branes – an explanation of sorts for why we see a universe with three dimensions. If large other dimensions do exist, particles escaping into them might take energy from those we see. CERN's Large Hadron Collider has been looking for the signatures of missing energy – so far without success.

Such failures rile Carlo Rovelli of the University of Aix-Marseille in France. "The idea that space could have more than three dimensions was proposed more than half a century ago and has delivered more disappointments than results," he says.

So we're back to the more basic question: why only three dimensions? Perhaps because some aspect of our universe wouldn't work otherwise. The precise degree of quantum weirdness we observe (see page 33) seems only possible in 3D space, for instance. And Susskind points out that in any other

"Atoms, planets and stars may not form properly with fewer than three dimensions"

number of dimensions the electromagnetic and gravitational forces would have very different strengths. With fewer than three spatial dimensions, for example, gravity does not lead to attractive forces. Atoms, planets and stars would not form properly – and humans would not be around to ponder the existence of dimensions.

Did such a peculiarly curiosity-friendly 3D universe arise as part of a "multiverse" in which every possible type of universe exists, a possibility espoused by string theory? Or is it just one of a kind? That's a toughie, but either way, we're still a distance away from explaining the essential three-ness of space, says Randall. "I think it would be lovely to have an answer, but as of now we don't."

Richard Webb

CAN WE GET ENERGY FROM NOTHING?

IT DEPENDS what you mean by nothing. Ask a physicist about a vacuum, the very definition of nothingness for most of us, and they will tell you it is pulsing with activity. According to quantum theory, in a vacuum wave-like fields are constantly fluctuating, producing particles and their antimatter equivalents that fizzle in and out of existence. So even in the depths of interstellar space, there is plenty going on in what we call zilch.

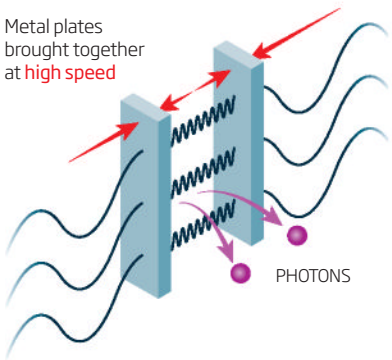
This idea leads to some outlandish predictions. In 1948, the physicist Hendrik Casimir proposed that if you place two parallel metal plates close to each other in a vacuum, there will be more quantum electromagnetic fluctuations either side of the plates than between them. Their proximity limits the wavelength of fluctuations in that space, creating a force pushing the plates together. The phenomenon became known as the Casimir effect.

It's a weakling force but it has been detected. And more recently, physicists like Chris Wilson, now at the University of Waterloo in Canada, have tried to prove another eccentric prediction: that it is possible to use the effect to release latent energy. Instead of allowing the fluctuations to tug on the plates, you rapidly force the plates together to squeeze their wavelengths – and force out photons (see diagram, below).

Trouble is, you can't accelerate even the tiniest mirror to the huge speeds required. So in 2011 Wilson and his colleagues tested the dynamical Casimir effect, as it's known, by using rapidly changing electrical currents to simulate the effect of minuscule mirrors whooshing together at a quarter of the speed of light.

Vacuum magic

In theory, we can turn quantum fluctuations in "empty" space into light if we squeeze their wavelengths rapidly enough



Sure enough, a pair of photons jumped out from the vacuum – energy, albeit a piffling amount, from thin air. "You can think of it as being like the mirror has knocked the particle into existence," says Wilson.

The experiment didn't produce energy overall: generating the currents required more than was produced. But harnessing the Casimir effect remains theoretically possible – and even a small success might go a long way.

Engineering the inside surfaces of the mirrors to manipulate fluctuating fields in a different way can create an outward pressure that pushes two objects apart. This reverse Casimir effect could come in handy when making switches for nanoscale devices. For now though, the build-up of electric charge between moving parts swamps the effect. And that's the least of the caveats. Some physicists still refuse to believe that quantum fluctuations in a vacuum are real, never mind the Casimir effect and its reversal.

Wilson is now refining his experiments to answer the criticism that he simply produced heat energy, a result of the apparatus warming up. And if he can show that the particles generated are entangled, as predicted by Casimir, that would provide the most convincing evidence yet that you really can get something from nothing.

Joshua Howgego

PETER MARLOW/MAGNUM

WHAT IS GLASS?

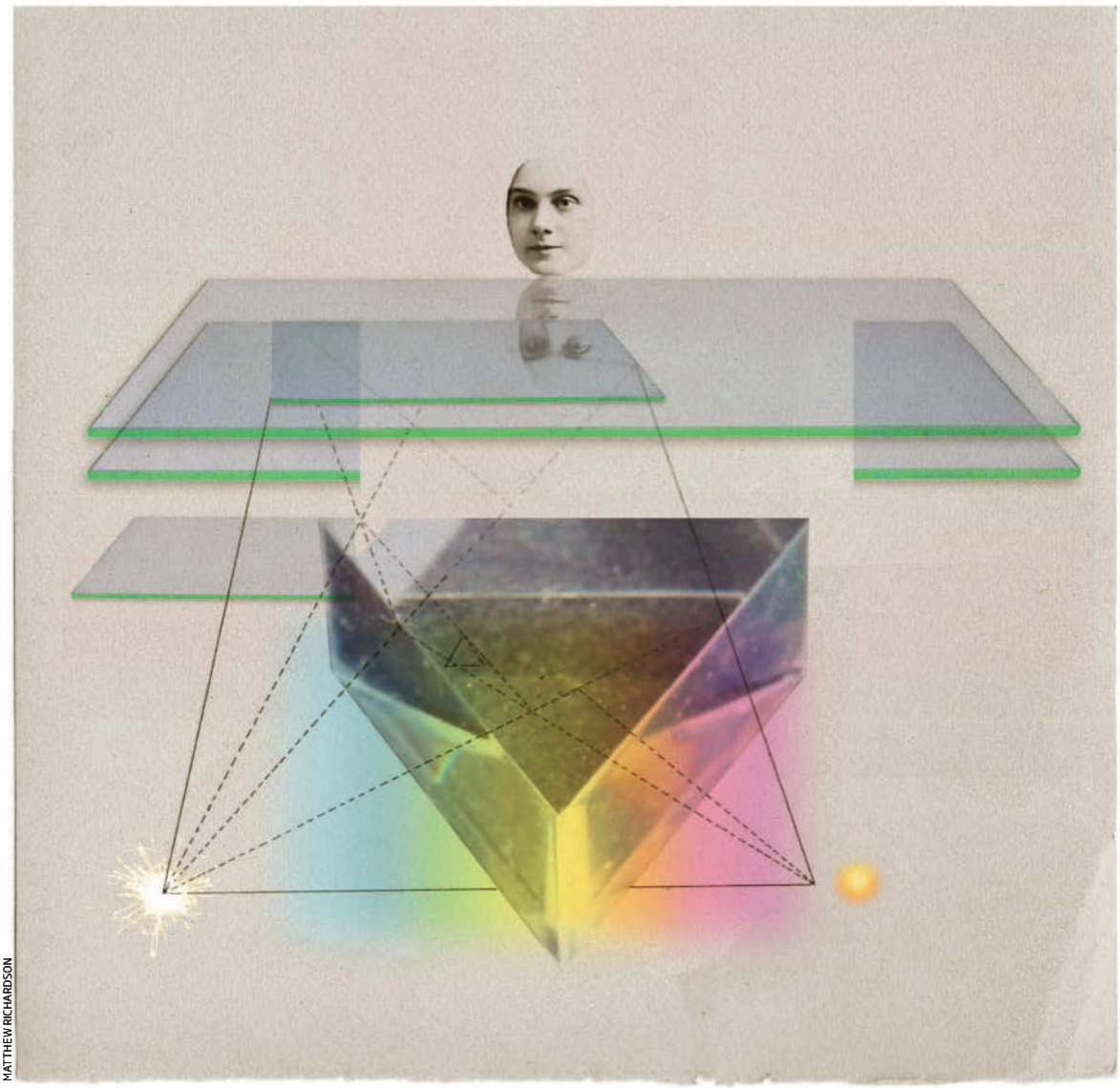
FORGET the hoary myths peddled by tour guides at old European churches and cathedrals. Medieval window panes are sometimes thicker at the bottom not because of the slow flow of glass over centuries, but because of the uneven way molten glass was originally rolled into sheets in the Middle Ages.

Glass is not a slow-moving liquid. It is a solid, albeit an odd one. It is called an amorphous solid because it lacks the ordered molecular structure of true solids, and yet its irregular structure is too rigid for it to qualify as a liquid. In fact, it would take a billion years for just a few of the atoms in a pane of glass to shift at all.

But not everything about glass is quite so clear. How it achieves the switch from liquid to amorphous solid, for one thing, has remained stubbornly opaque.

When most materials go through this transition between liquid and solid states, their molecules instantly rearrange. In a liquid the molecules are moving around freely, then snap! – they are more or less locked into a tightly knit pattern.

But the transition from the glassblower's red-hot liquid to the transparent solids we drink from and peer through doesn't work like that. Instead of a sudden change, the movement of molecules gradually



MATTHEW RICHARDSON

slows as the temperature drops, retaining all the structural disorder of a liquid but acquiring the distinctive physical properties of a solid. In other words, in all forms of glass we see something unusual: the chaotic molecular arrangement of a liquid locked in place.

The process underlying this strange behaviour remains an open question. "The number of explanations almost matches the number of researchers," says Hajime Tanaka at the University of Tokyo in Japan.

"It would take a billion years for just a few of the atoms in a pane of glass to shift at all"

One possibility is that it's all down to energy use. According to the laws of thermodynamics, which govern how energy is transferred within a system, every collection of molecules is driven to find an arrangement with the lowest possible energy. But within any given system some patches do better than others, meaning different groups of molecules settle into different configurations – and, overall, into an irreconcilably chaotic arrangement.

But even if we put it down to thermodynamic laws, it's not clear what exactly drives glass's strange behaviour. The push for low energy might be the prime mover. Then again, it could be the irrepressible tendency towards a maximum state of disorder. That's a perfectly plausible proposal, though it raises the troubling question of how ordered solids manage to survive.

Tanaka is not giving up just yet. "So far crystallisation and glass transition have been studied independently," he says. But Tanaka believes that glass may form in a manner not all that different from crystals, which have proved an easy target for analysis thanks to their repeating geometric structures. If he's right, maybe glass will finally become crystal clear.

Gilead Amit

WHY IS ICE SLIPPERY?

JOSH HANER/EYEVINE

FOR physicists no less than figure skaters, ice is remarkably hard to get a grip on. The overwhelming consensus is that ice has low friction because of a thin film of liquid water coating its surface. Hence skaters balanced on thin metal blades can glide smoothly across the ice rink, but grind to a halt on the wooden floor beyond. The tricky part is how this liquid layer forms. More than a century of research has brought us little closer to a definitive answer.

It all started in June 1850, when Michael Faraday told an audience at London's Royal Institution of how pressing two ice cubes together led to them forming a single block. He attributed this to the appearance of an intervening film of water that quickly refreezes. For many years, the appearance of this layer of water was put down to pressure. In fact, even a person of above-average weight on a single skate generates far too little pressure to account for the observed melting, says Anne-Marie Kietzig of McGill University in Montreal, Canada. "The mathematics doesn't work out."

Instead, Kietzig argues that the main player is frictional heating. The movement of a blade across the ice, for instance, easily generates enough heat to melt some of it.

You might think that would be the end of it. But Changqing Sun of Nanyang Technical University in Singapore has other ideas. He argues that since ice is slippery even when you're standing still, friction cannot be the whole story. "Mechanisms such as friction heating and pressure melting have been ruled out," he says.

According to Sun, the assumption that the slippery layer coating ice is a liquid is also fundamentally flawed. He says this layer should properly be called a "supersolid skin" because the weak bonds between H_2O molecules at the surface are stretched, but unlike in liquid water none of them are broken. He also argues that this elongation of bonds ultimately produces a repulsive electrostatic force between the surface layer and anything it comes into contact with (see diagram, left).

"Even with something as familiar as ice, reality is much more complicated than we expected"

He compares the effect to the electromagnetic force that levitates Maglev trains, or the air pressure a hovercraft generates beneath its hull. If he's right, his model helps to explain many of the layer's properties, including its remarkably low friction. "I believe the problem has been completely resolved," says Sun.

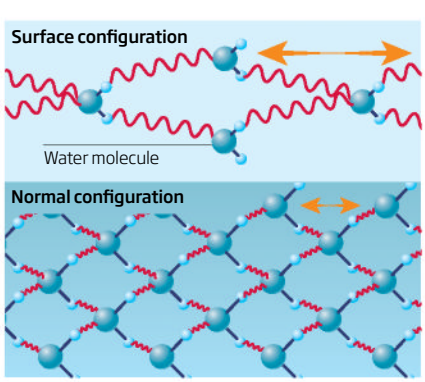
Most in the ice field are not convinced. Gen Sazaki at Hokkaido University in Sapporo, Japan, who made the first direct observations of this layer in 2013, prefers to call it a quasi-liquid. He thinks it represents a transitional stage between solid and liquid as the temperature goes up.

For Sazaki, understanding how this mysterious sheet of H_2O forms is still some way off. Even when it comes to something as familiar as slipping on ice, he says, "reality is much more complicated than we expected".

Gilead Amit

Slip sliding away

Hydrogen bonds in a supersolid surface ice layer would be longer and springier than in the normal solid – increasing **side-to-side motion** and making it more slippery



HOW LONG DOES A PROTON LIVE?

THE BIBLE of fundamental physics, *The Review of Particle Physics*, devotes several pages to the ways a proton might fall apart. Each "decay mode" comes with an estimate of how long you might expect to wait to see one of these particles, bedrocks of the atomic nucleus, disintegrate that way. The units are 10^{30} years – thousands of billions of billions of billions of years. Our stripling universe is a mere 13.8 billion years old, so this is a judicious, scientific way of saying that no one has ever seen a proton decay.

It's not for want of looking. Super-Kamiokande, a 50,000-tonne tub of ultra-pure water under a mountain in central Japan, is one place where researchers are watching out for the pop and fizzle of a dying proton. Late last year, the team published its latest estimate for how often one particularly eagerly sought decay mode occurs: at most once every 5.9×10^{33} years.

You'd think people would be pleased that the particles we're all made of are stable. Physicists too: their "standard model" of particle interactions firmly indicates that protons, as the lightest particles constructed of three quarks, should never decay.

So why is "never" not good enough? The answer is that few believe the functional but ramshackle standard

"Should we be worried if one of the fundamental components of you and me is a little wobbly?"

model is up to snuff. So-called grand unified theories provide a more coherent account of three of nature's forces – gravity remains aloof – at the price of the proton decaying. "It's the signal of a grand unified theory," says Benjamin Allanach, a theorist at the University of Cambridge.

Not only that, but these ambitious models predict the proton should live for somewhere between 10^{30} and 10^{35} years – just the range experiments are now probing. "We're entering the really interesting area where you can start to rule these theories out," says Allanach. "Or if they are correct, you should start seeing protons decay." It could be a long wait: pushing the minimum lifetime up by a factor of 10 means watching for 10 times as long.

So should we be worried if one of the fundamental components of matter, the stuff that makes up you and me, proves to be a little wobbly? Not really: our bodies do not make good observatories for proton decay. "From my back-of-the-envelope calculation, it would be a rare person that would experience a proton decay in their lifetime," says Allanach. And the universe has so many protons that we'll be long gone before they run out.

In the meantime, here's the best answer we have for the lifetime of a proton: a very, very long time.

Richard Webb

IS THE UNIVERSE INFINITE OR JUST VERY BIG?

WE'VE known the size of Earth since the time of the ancient Greeks. The sun, solar system and Milky Way? No problem. But when it comes to the size of the universe, we haven't got a clue.

"It's weird: the size of the observable universe is one of the more precisely known quantities in astronomy, but the size of the whole universe is one of the least well-known," says Scott Dodelson, a cosmologist at Fermilab in Batavia, Illinois.

One way to think about the size of the observable universe is to consider how far light emitted at the big bang could have travelled by now. According to our best cosmological models, that distance is about 46 billion light-years. This is the cosmic "horizon", a sort of three-dimensional equivalent of the 2D-horizon we see on Earth.

"That is as far as we can see and how big, empirically, we can observe the universe to be," says Adam Riess of Johns Hopkins University in Baltimore, Maryland, who shared the Nobel prize in 2011 for the discovery that the universe's expansion is accelerating. "Of course we are pretty sure it goes out much farther."

Why? Because the universe looks very similar no matter which way you look. Take the cosmic microwave background (CMB), the radiation left behind by the big bang. It is largely uniform across the sky, and we have no reason to think that would change beyond the cosmic horizon. There are no signs the universe is tailing off, so it would be a surprise if it abruptly ended.

Daniel Eisenstein of the Harvard-Smithsonian Center for Astrophysics says that if the universe is only a little bit larger than what we see, we might expect to find hints of structures much larger than galaxy filaments – formations of superclusters of galaxies. These hints would show up as wild variations in the temperature map of the CMB.

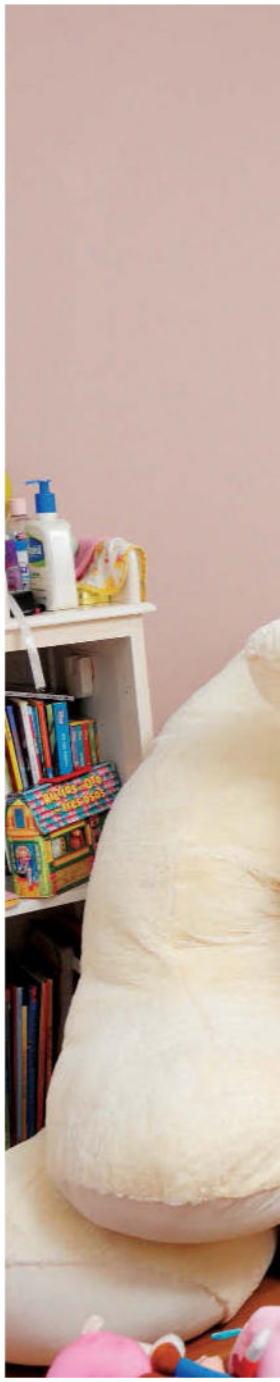
But they don't, which implies that the universe is much larger than our little observable corner. If that's the case, Eisenstein says it will be a struggle to figure out how big it is. "It might be a million times larger, or a trillion, or even infinite."

A truly infinite universe might be tough for us to comprehend. Particularly perplexing is the idea that if the universe is infinite now then it must always have been so, even during the earliest moments in its history when the distances between objects were much smaller. But we would have to go a long way to rule it out.

MacGregor Campbell

YOU GOTTA BE KIDDING

Can having children really be all that bad? **Georgia Grimmond** investigates



Sometimes you just need a bear hug

THIS October, the first conference dedicated to women without children will be held in Cleveland, Ohio. At The Not Mom Summit, academics, writers and inspirational speakers will cover topics like dating, volunteering and voting.

It's a growing movement. Across the Western world, record numbers of people are remaining childless. In the UK, one in five women have no children by the age of 44. In the US, the picture is similar for both genders, and the number of childless women has almost doubled since the 1970s. While many people may want kids but can't have them, some are simply rejecting what was once considered an inevitable and essential part of the human experience – procreation.

Perhaps that's not so surprising. Having children can have a significant impact on finances, careers and the planet. More surprising is the growing body of evidence that it can also make you less healthy and less happy. But can the situation really be that gloomy?

No kidding, children in the wealthy West are a huge financial drain. The average middle-class US family has spent more than $245,340 on each child by the time they're 18. In the UK, the cost of raising a child has swelled 63 per cent since 2003, with childcare alone eating up 27 per cent of the average salary, according to the Centre for Economics and Business Research in London. Luca Stanca, an economist at the University of Milano-Bicocca, Italy, puts it bluntly: "On the basis of a purely economic approach, the optimal number of children for a rational agent is zero."

Finances aside, there's an environmental question when it comes to deciding whether to have kids. Children, though small, can come with a large environmental footprint. In the US you can recycle and bike to work all you want to reduce your carbon emissions, but those gains will be 20 times less than the CO_2 impact of having a child, according to a 2009 study from Oregon State University. The United Nations projects that "if current population and consumption trends continue, humanity will need the equivalent of two Earths to support itself by 2030". Some have taken this message to heart. Environmentalist Bill McKibben struggled with the decision of whether to have children, and ultimately opted for one, defending his choice in his book *Maybe One: A case for smaller families*. The Voluntary Human Extinction Movement even urges people not to add to the "burgeoning billions already squatting on this ravaged planet", seeing the only sustainable future as one without humans.

That's an extreme view. But there is now almost half a century of evidence on the relationship between having children and personal happiness that might give more people pause for thought. Contrary to what we might think, study after study has shown that having children does not seem to make people happier, and in fact may even make them a little less happy. "The great majority of studies find no effect or a negative effect," says economist Andrew Oswald of the University of Warwick, UK.

Having children makes couples less happy with their sex lives, is associated with depression, sleep-deprivation, and, as one study puts it, "hastens marital decline". One oft-cited 2006 study co-authored by Princeton psychologist Daniel Kahneman found that a ›

ALDO SPERBER/PICTURETANK

THE PATERNAL URGE

Having children may not necessarily increase happiness (see main story), but mothers tend to love them anyway. This is in part because of the changes that occur in a woman's body and mind after she becomes pregnant. But what about fathers?

For anthropologist Susan Hrdy of the University of California, Davis, the stereotype of the detached dad isn't true. "In my lifetime I have had to completely revise the way I think about the nurturing potential in men. It's there," she says.

Take hormones. In 2011, the first comprehensive study to follow men before and after having children showed that fathers' testosterone levels were lower than those of their childless peers. Dads who spent 3 or more hours a day caring for their child had the lowest levels. The researchers suggest that the change allows men to switch from mating mode – where testosterone-fuelled competitiveness and musculature is an advantage – to parenting mode, where caring, attentive behaviours are important to reproductive success.

Parenthood can also change a man's brain, according to a study published last year. Researchers scanned fathers' brains twice: two to four weeks and three to four months after their child's birth. The grey matter in the men's brains swelled in areas associated with parenting behaviours such as responding to a baby's cries.

"Across the West, record numbers of people are remaining childless"

THAT BROODY FEELING

Why do people think having kids will make them happier, if the evidence suggests otherwise?

One explanation offered by psychologists is that we are simply bad decision-makers. "Generally, people are quite poor at knowing what will make them happy," says Andrew Oswald, an economist at the University of Warwick, UK. And once people decide to have kids, there's no going back, which means it's in parents' interest to put a positive spin on it. "There's not much point sitting around and saying, 'This was a bloody mistake'," says Oswald. "Humans will do the best to convince themselves they've done the right thing."

Our cognitive biases influence us too. Looking back on experiences, we tend to remember high points such as a child's first smile, says economist Nattavudh Powdthavee of the London School of Economics – a phenomenon known as the focusing illusion. This mental shortcut means we may overestimate how much happier children and many other things have made us.

What about an inbuilt desire to breed? According to anthropologist Susan Hrdy of the University of California, Davis, the desire for children is cultural, not hardwired. "There wasn't any need for Mother Nature, and by that I mean Darwinian natural selection, to build in 'Oh I've got to have children'," she says. In the past "any female with enough fat to ovulate was going to get pregnant", says Oswald. "The heaviest selection pressure was on her striving for local clout to be able to defend the resources that she needs to get that fat on board."

Once we have a child, nurturing instincts kick in. A female "didn't have to want that baby, but once it came there are processes in place to make her bond with the baby", says Hrdy. But before that, to make us have children, "all nature has to do is make us enjoy sex".

> "On the evidence, it might seem utter folly for couples to take the parenthood plunge"

group of working US mothers ranked childcare 16th out of 19 everyday tasks in terms of positive feeling, just ahead of commuting to and from work, and work itself.

This year, Daniel Hamermesh of Royal Holloway, University of London, and his colleagues published a study of more than 14,000 Australian and German couples, finding that mothers reported a sharp rise in stress after the birth of a child – three times that of the father – and that it increased year-on-year until four years after the birth, when the study stopped. A study published last month, which followed more than 2000 first-time German parents, found that the average hit to happiness exacted by the arrival of an infant is greater than a divorce, unemployment or the death of a spouse.

On this basis, it might seem utter folly for couples to take the parenthood plunge. "If you believe that having children will make you substantially happier, then, on average, you're wrong," says Oswald.

Sonja Lyubomirsky, a psychologist at the University of California, Riverside, began to doubt that black-and-white picture a few years ago. "It didn't make sense that parenthood wouldn't make us happy," she says. "How would we survive as a species if no one wanted to be a parent?" In 2012, she and her colleagues published a paper in the journal *Psychological Science*, showing that having children made men (but not women) happier. It garnered a lot of press attention for suggesting that researchers had got the wrong end of the stick on parental happiness.

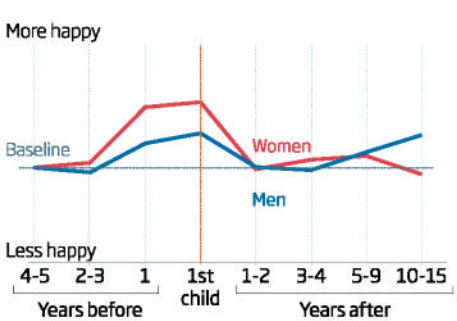
But others questioned that conclusion. Saurabh Bhargava, an economist at Carnegie Mellon University in Pittsburgh, Pennsylvania, published a critique in 2014 in the same journal. His criticism was that by comparing a largely married population with kids with a largely unmarried population without kids, Lyubomirsky's study failed to control for another factor that might be responsible for the happiness boost: being married. "One of the most robust effects in the happiness literature is the effect of marriage on well-being," Bhargava says.

Lyubomirsky agrees that "marriage is one of the key alternative explanations". Still, in a response to the critique, she and her colleagues stated that they were not trying to prove that children make people happier. "Motivated in part by media portrayals of parents who are 'miserable' and who 'hate parenting,' we simply asked whether happiness and parenthood can coexist," they wrote.

This idea is backed up by research done in 2014 by Angus Deaton of Princeton University and Arthur Stone of Stony Brook University in New York state. "We ask: Is it true that people with kids are happier than people who don't have kids? And the answer to that question is yes," says Deaton. "But the people who have kids have all sorts of differences from the people who don't have kids. They have more money, they're more religious, all these sorts of things." When Deaton and Stone controlled for those variables, the correlation between children and increased well-being disappeared.

The happiness bump

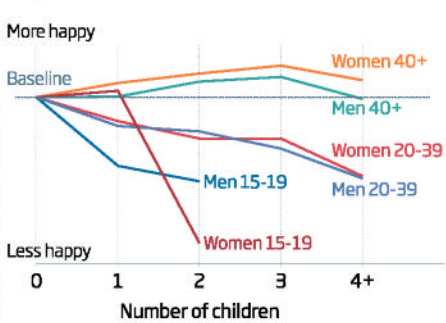
UK parents feel joy when anticipating the arrival of their first child, but their happiness drops again after birth



SOURCE: DEMOGRAPHY 2014 OCT; 51(5):1843-66

A numbers game

Children have differing effects on happiness depending on how many you have and how old you are



SOURCE: POPUL DEV REV 2011; 37(1): 29-56

MARTIN PARR/MAGNUM PHOTOS

JEAN-MARC CAIMI/MILLENNIUM IMAGES, UK

A pet can't look after you when you're older

Such niggles show just how complex parenthood and happiness are to study. "If you want to understand the causal effect of sleeping pills on somebody's sleep, you can run placebo trials," says Oswald. "You can't for children." Kids can't be handed out at random to see what effect they have on people.

Social support

One way round this problem is with a before-and-after study of the same people. Their lesson seems to be that parents' happiness increases a year or so before the birth of the first child, and then returns to pre-birth levels by the time the baby is about one (see "The happiness bump", left).

So the true picture is clearly more nuanced than a blanket "kids make you unhappy". Stanca has recently found that parenthood tends to boost people's satisfaction with their lives apart from their financial circumstances – but for most people, the money woes associated with children were so great that any additional happiness they felt was swallowed up. "Children do make us happy," he says, "provided we can afford them – or think so."

A parent's age may matter too. In a study across 86 countries, Mikko Myrskylä of the Max Planck Institute for Demographic Research in Rostock, Germany, and Rachel Margolis of the University of Western Ontario in Canada discovered that for people younger than 30, children are associated, on average, with a decrease in happiness. From 30 to 39, the average effect on happiness is neutral, and at age 40 and above, it's positive. For them, it's the more, the merrier, to a point – three seems to be the optimal number (see "A numbers game", below left). Such effects suggest, say the researchers, that having kids may be a "long-term investment in well-being."

Then, of course, there's the question of where you live. Parents in the 20 to 29 age group tend to sustain a large hit to their happiness by having children, but Margolis and Myrskylä found the generous welfare systems in countries such as Sweden, Japan and France soften the blow. The most happy parents over 40 live in former socialist states such as Russia and Poland, where care of the elderly falls mostly to the family, so having children is a boon in later life. In countries with less generous welfare systems such as the UK, there is a slight indication of decreased happiness with the arrival of the first child.

Indeed, comparing happiness levels between parents and non-parents within a country, and then between countries, can serve as a sort of global barometer. In a study currently under review, sociologist Robin Simon of Wake Forest University in Winston-Salem, North Carolina and her colleagues look at 22 countries and find that the happiness gap in the US between those with and without children is wider than in the majority of the other countries studied where provision for parents is often more generous. "Having kids in the US is brutal," Simon says. "The federal government requires that workplaces give six weeks maternity leave, but there is no requirement that it is paid. We just don't do anything to assist parents."

Simon believes it is this lack of support in the US and probably other countries that wipes out one gain you would expect to find even among less happy parents – a sense of greater purpose. In ongoing work looking at 12 indicators of well-being, including physical health, self-acceptance and sense of purpose, Simon and her colleagues found that none, except lower alcohol use, was associated with parenthood in the US. "I thought at least purpose and meaning in life would be higher for parents," she says, "and we find it's just flat."

Parental well-being, then, would seem to be a lottery. Children themselves probably don't make you less happy – but external factors might. If you're lucky enough to be married, well-off, or a resident of a Nordic country with generous social provision, you have a better chance of enjoying parenthood. For the rest, it may not be the experience they had hoped it would be.

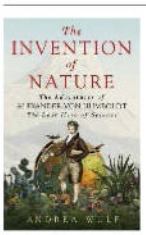
Despite the gloomy picture, the vast majority of people still would like to have children, so, for Simon, the solution is to create a society that allows more of us to reap the rewards of parenthood. "There is joy to having kids," she says. "But I think that for most people, the stresses that are associated with having kids overshadow those joys." ■

Georgia Grimmond is a journalist based in the UK. Additional reporting by **Sonia van Gilder Cooke**

Nature's poet

His fame once rivalled Napoleon's, yet naturalist Alexander von Humboldt ended up largely forgotten, finds **Stephanie Pain**

The Invention of Nature: The adventures of Alexander von Humboldt, the lost hero of science
by Andrea Wulf, John Murray, £25



WHEN the young Charles Darwin set off round the world on HMS Beagle in 1831, he took with him only those books he felt essential. The ship was small, his cabin cramped and Darwin had to limit his library to what would fit on one small shelf.

He chose the Bible and a few key works on botany, zoology and geology. Then, after asking special permission from the captain, he added Alexander von Humboldt's *Personal Narrative*, a weighty seven-volume account of the Prussian naturalist's travels in South America 30 years earlier.

Humboldt was Darwin's hero: his vivid descriptions of the tropics and revolutionary ideas about nature were the reason Darwin signed up for the Beagle.

Historian Andrea Wulf calls Humboldt the lost hero of science. It is extraordinary that a man once so revered is now largely forgotten, the more so given his name is dotted over maps of half the world, attached to mountains, lakes, rivers and towns – and even to a "sea" on the moon. Humboldt is also the name of an ocean current, a penguin and a long list of other animals and plants.

During his long life, however, the naturalist, aristocrat-turned-revolutionary and writer of some of the most influential books of the 19th century was a guiding light to generations of scientists, poets and politicians who are now far more celebrated than he is. For a while, he had the world at his feet, and was considered the most famous man after Napoleon.

In this gripping study, Wulf follows Humboldt from his stifling youth in Prussia to the liberating rainforests of South America, where, during an arduous five-year expedition, he dodged crocodiles on the Orinoco and fell asleep to the sound of snoring river dolphins.

On the flooded grasslands of Venezuela's Los Llanos, he discovered electric eels and tested their potentially lethal power. In the Andes, despite an injured foot, he climbed higher than anyone before as he tried to reach the peak of Chimborazo, a volcano then thought to be the world's highest mountain. And all because he believed that to understand nature you couldn't just study it but had to experience it.

A drawing of a New World monkey in Humboldt's *Personal Narrative*

BOTTOM LEFT: BPK/STAATSBIBLIOTHEK ZU BERLIN; MAIN: BPK/SPSG, BERLIN-BRANDENBURG/HERMANN BURESCH

Humboldt's trip to South America inspired Darwin to join the Beagle

From the beginning, Humboldt approached the natural world in a different way to most scholars. While they collected, named and classified, he looked at the bigger picture. He saw nature in terms of what we now call ecosystems. Life wasn't a matter of individual plants and animals but a web in which everything was linked. As he wrote: "In this great chain of causes and effects, no single fact can be considered in isolation." Break one link and the whole would fall into disarray.

But taking a broad view didn't mean ignoring the detail. Far from it. Humboldt was obsessed with data. He had instruments to measure everything, even the blueness of the sky, lugging them from one side of South America to the other.

Wherever he went, he recognised patterns, spotting similarities in the types of plants growing in widely separated parts of the world, thereby identifying the vegetation zones that girdle the globe. And climbing in the high Andes, he saw stretched out below the same phenomenon, with altitude rather than latitude dictating what grew where.

His travels also opened his eyes to the horrors of colonialism and the damage done to both people – he was a fierce opponent of slavery – and the environment. Land cleared to grow cash crops for Spanish landowners, wrote Humboldt, soon became dry and barren. He recognised the role forests play in controlling local climate – and how the loss of trees would change it.

Years later, Humboldt wrote about how people were changing the environment, and listed three ways in which humans were affecting climate: deforestation, ruthless irrigation, and the "great masses of steam

and gas" produced in the world's industrial centres. As Wulf suggests, Humboldt was the unrecognised great-grandfather of environmentalism.

But the key to his fame was undoubtedly the way he wrote. Immersed in culture from his youth, his social circle included artists and poets, among them the German poet Goethe. The result, says Wulf, was that Humboldt the

"Humboldt was the unrecognised great-grandfather of environmentalism"

scientist wrote like a poet. French writer François-René de Chateaubriand thought his writing so evocative that "you believe you are surfing the waves with him, losing yourself with him in the depths of the woods".

Humboldt's accounts of his travels were translated, pirated and sold worldwide, and they won him legions of admirers. Poets mined his writing for ideas; Simon Bolivar, liberator of Spain's South American colonies, saw his homeland through Humboldt's eyes and was inspired to start a revolution. "With his pen", said Bolivar, Humboldt had awakened South America. And aboard the Beagle, Darwin read and re-read Humboldt's account of the tropics, turning over the great man's ideas while he formulated his own.

Wulf has delved deep into her hero's life and travelled widely to feel nature as he felt it. "Humboldt gave us our concept of nature itself," says Wulf. "The irony is that Humboldt's views have become so self-evident that we have largely forgotten the man behind them." No one who reads this brilliant book is likely to forget Humboldt. ■

Stephanie Pain is a consultant for *New Scientist*

Melancholy memories

The cloud is as much about loss as about remembering, finds **Simon Ings**

A Prehistory of the Cloud by Tung-Hui Hu, MIT Press, $25

LAST week, to protect my photographs of a much-missed girlfriend I told all my back-up services to talk to each other. My snaps have since been multiplying like the runaway brooms in Disney's *Fantasia*, and I have spent days trying to delete them.

Apart from being an idiot, I got into this fix because my data has been placed at one invisible but crucial remove in the cloud, zipping between energy-hungry servers scattered across the globe at the behest of algorithms I do not understand.

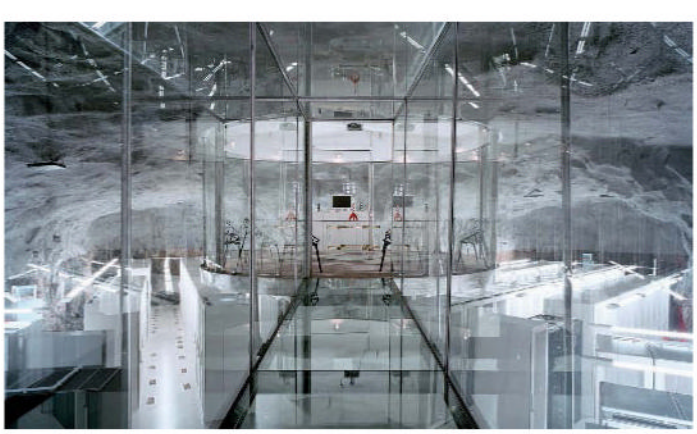
By duplicating our digital media to different servers, we insure against loss. The more complex and interwoven these back-up systems become, though, the more insidious our losses. Sync errors swallow documents whole. In the hands of most of us, JPEGs degrade a tiny bit each time they are opened. And all formats fall out of fashion eventually.

"Thus disaster recovery in the cloud often protects us against the disaster of the cloud itself," says Tung-Hui Hu, a former network engineer whose *A Prehistory of the Cloud* poses some hard questions of our digital desires. Why are our commercial data centres equipped with iris and palm recognition systems? Why is Stockholm's most highly publicised data centre housed in a bunker originally built to defend against nuclear attack?

Hu identifies two impulses: "First, a paranoid desire to pre-empt the enemy by maintaining vigilance in the face of constant threat, and second, a melancholic fantasy of surviving the eventual disaster by entombing data inside highly secured data vaults."

The realm of the cloud does not countenance loss, but when we touch it, we corrupt it. The word for such a system – a memory that preserves, encrypts and mystifies a lost love-object – is indeed melancholy. Hu's is a deeply melancholy book and for that reason, a valuable one. ■

Loss... entombing memories in secure vaults may not save us



PERCY FEINSTEIN/CORBIS


News
After handshakes, we sniff people's scent on our hand
After handshakes, we sniff our hand
YouTube
This suggests that handshakes might transmit chemical signals
You won't believe you do it, but you do. After shaking hands with someone, you'll lift your hands to your face and take a deep sniff. This newly discovered behaviour – revealed by covert filming – suggests that much like other mammals, humans use bodily smells to convey information.
We know that women's tears transmit chemosensory signals - their scent lowers
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Harvard University
Faculty of Arts and Sciences, Cambridge, MA
Department of Chemistry & Chemical Biology

TENURE-TRACK PROFESSOR

Position Description: The Department of Chemistry & Chemical Biology seeks to appoint a tenure-track assistant professor in the open field of chemistry and chemical biology. The appointment is expected to begin on July 1, 2016. The tenure-track professor will be responsible for teaching at the undergraduate and graduate levels.

Basic Qualifications: Doctorate or terminal degree in chemistry or related discipline required by the time the appointment begins.

Additional Qualifications: Demonstrated excellence in teaching is desired.

Special Instructions: Please submit the following materials through the ARIeS portal (http://academicpositions.harvard.edu/postings/6320). Applications must be submitted no later than October 15, 2015.

1. Cover letter
2. *Curriculum Vitae*
3. Teaching statement (describing teaching approach and philosophy)
4. Outline of future research plans
5. Names and contact information of 3-5 references (three letters of recommendation are required, and the application is complete only when all three letters have been submitted)
6. List of publications

Harvard is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability status, protected veteran status, or any other characteristic protected by law.

Contact Information: Helen Schwickrath, Search Administrator, Department of Chemistry & Chemical Biology, Faculty of Arts and Sciences, Harvard University, 12 Oxford St., Cambridge, MA 02138. Phone: (617) 496-8190.

Contact Email: Helen@chemistry.harvard.edu

Washington University in St. Louis

Faculty Positions in Biochemistry and Molecular Biophysics

The Department of Biochemistry and Molecular Biophysics at Washington University School of Medicine invites applications for several tenured/tenure-track faculty positions at the level of Assistant/Associate/Full Professor. Successful candidates will have established a strong record of research. Applicants seeking tenured positions must have a strong record of external funding.

Outstanding individuals working in any area of biochemistry and molecular biophysics are encouraged to apply. The candidate's research should be aimed at addressing fundamental questions related to molecular mechanisms of biological or biomedical relevance. Current research in the department spans a wide range of topics including computational biology, membrane proteins, molecular motors, nucleic acid / protein interactions, protein structure, enzymology and signal transduction. Additional information about the department is available at **http://www.biochem.wustl.edu**. Washington University has a highly interactive research environment with vigorous interdisciplinary graduate and medical scientist training programs.

Applicants should email their curriculum vitae, brief description of their research interests, and contact information of three individuals to the Search Committee at **bmbsearch@biochem.wustl.edu**. The committee will request letters from these individuals as necessary.

Completed applications will be reviewed on a rolling basis, starting immediately. For full consideration, applications should be received by December 1, 2015.

EOE/Minorities/Vets/Disabilities. The School of Medicine at Washington University is committed to finding solutions to global health problems, including ones that affect minority and disadvantaged populations.

LSA COMPLEX SYSTEMS
UNIVERSITY OF MICHIGAN

ASSISTANT PROFESSOR in Complex Systems

The Center for the Study of Complex Systems (CSCS) at the University of Michigan invites applications for a tenure-track position of Assistant Professor of Complex Systems. Candidates at a more senior-level will also be considered. The appointment will begin **September 1, 2016**. This is a University-year appointment. Information about the Center can be found here: **http://www.lsa.umich.edu/cscs**.

Required Qualifications
Candidates must have a demonstrated research agenda focusing on complex systems. This may involve theoretical or applied research on complexity, including (but not limited to) mathematical and computational models in areas such as networks, computation, emergence, large events and robustness or applications where complexity lies at the core such as quantitative modeling of social systems, soft condensed matter physics, evolutionary or ecological dynamics, epidemiology and disease transmission, artificial life, neuroscience, and cognition. Preference will be given to candidates with a track record of working across disciplines.

How to Apply
All application materials must be uploaded onto this website:
https://complexsystems-lsa.applicantstack.com/x/apply/a2guio5y9cxr

The position is based in CSCS but will be a joint appointment with another department. In the cover letter, candidates should identify one or more partner departments at the University of Michigan suitable for such a joint appointment. Applicants must submit: a current CV, statement of current and future research plans, a statement of teaching philosophy and experience, evidence of teaching excellence (if any) and one writing sample. At least three letters of recommendation are required and must be uploaded onto the same website. Applications will be reviewed starting **October 1, 2015**. Applications will be accepted until the position is filled.

Women and minority candidates are encouraged to apply. The University of Michigan is an equal opportunity/affirmative action employer and is supportive of the needs of dual career couples.

THE UNIVERSITY of WISCONSIN MADISON

MANAGING DIRECTOR

Center for Sustainable Nanotechnology PVL 83199

The Department of Chemistry of the University of Wisconsin-Madison is recruiting for a Managing Director in the Center for Sustainable Nanotechnology (CSN.) The Director works with the Center Director and the CSN Executive Committee and is responsible for actively directing and coordinating scientific research and additional integrative activities at multiple institutions to achieve the center's goals. A Ph.D. in Chemistry or related field experience is required. This is a full-time position with an anticipated beginning date of **October 1, 2015**. There will be a minimum twelve-month evaluation period.

Specific duties of the Director may include: Overseeing general operation of the center; establishing and implementing center-wide policies and procedures that will maximize the effectiveness of the center's scientific objectives and associated integrative activities; oversee center-wide finances (including multiple sub-contracts) and develop financial plans for the center; ensure that Center programs and activities are compliant with federal/state regulations; interface directly with federal agency personnel to meet reporting requirements and to communicate the center's scientific progress and objectives. This will include identifying high-impact scientific results and translating into language appropriate for program managers and policymakers.

For additional information, please go to:
http://www.ohr.wisc.edu/Weblisting/External/PVLSummary.aspx?pvl_num=83199
Additional information on the Center for Sustainable Nanotechnology is available at
http://susnano.chem.wisc.edu

Please submit a letter of interest, curriculum vita and 3 references referring to **PVL 83199 to Dennis Reece at the Department of Chemistry, University of Wisconsin-Madison, 1101 University Ave., Madison, Wisconsin 53706-1322.**

To guarantee full consideration, all materials must be received by **September 15, 2015**.

The University of Wisconsin is an equal opportunity and affirmative action employer; applications from qualified women and minority candidates are encouraged. Unless confidentiality is requested in writing, information regarding the identity of the applicant must be released on request and there are deadlines for disclosure. Finalists cannot be guaranteed confidentiality. A background check may be required prior to employment

THE UNIVERSITY OF CHICAGO

Assistant Professor of Chemistry

The Department of Chemistry at The University of Chicago invites applications from outstanding individuals for the position of Assistant Professor of Chemistry. This search is in the areas broadly defined as inorganic, organic and physical chemistry. Applicants must apply online to the University of Chicago Academic Career website.

Inorganic chemists apply to **http://tinyurl.com/nq59kgr**, Organic **http://tinyurl.com/oxvy7n8**, and Physical **http://tinyurl.com/py98uyk**.

Please apply to one search only. Applicants must upload a cover letter, a curriculum vitae with a list of publications, a succinct outline of research plans and a one page teaching statement. In addition, three reference letters are required. At the time of hire the successful candidate must have a Ph.D. in Chemistry or a related field. Joint appointments with other departments are possible. Review of applications will continue until all positions are filled.

Referral letter submission information will be provided during the application process.

All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, age, protected veteran status or status as an individual with disability.

The University of Chicago is an Affirmative Action / Equal Opportunity / Disabled / Veterans Employer.

Job seekers in need of a reasonable accommodation to complete the application process should call 773-702-5671 or email ACOppAdministrator@uchicago.edu with their request.

RADCLIFFE INSTITUTE FOR ADVANCED STUDY HARVARD UNIVERSITY

Academic Fellowships

The Radcliffe Institute Fellowship Program at Harvard University welcomes fellowship applications in natural sciences and mathematics. The Radcliffe Institute for Advanced Study provides scientists the time and space to pursue their career's best work. At Radcliffe you will have the opportunity to challenge yourself. Meet and explore the work of colleagues in other fields. Take advantage of Harvard's many resources, including the extensive library system. Radcliffe Institute Fellowship Program invites applications from people of all genders, and from all countries. We seek to build a diverse fellowship program.

Scientists in any field who have a doctorate in the area of the proposed project (by December 2014) and at least two published articles or monographs are eligible to apply for a Radcliffe Institute fellowship. The stipend amount of $75,000 is meant to complement sabbatical leave salaries of faculty members. Residence in the Boston area and participation in the Institute community are required during the fellowship year.

Applications for 2016-2017 are due by October 15, 2015.

For more information, please visit www.radcliffe.harvard.edu or email sciencefellowships@radcliffe.harvard.edu.

Schulich MEDICINE & DENTISTRY

Western

Call for Applications
Chair,
Department of Medical Biophysics

The Schulich School of Medicine & Dentistry, at Western University, is inviting applications for the position of Chair in the Department of Medical Biophysics.

As Canada's first Department of Biophysics, the Department has grown to become one of Canada's leading centres for medical biophysics research with approximately 20 primary faculty members and over 70 actively collaborating cross appointed faculty leading internationally recognized research programs in medical imaging, microcirculation, computational modelling, biomechanics, and cancer. The department is the academic home to both undergraduate and graduate programs, including CAMPEP accreditation. It draws on a rich city-wide infrastructure incorporating two research Institutes, three hospitals, and five University Faculties. Research programs benefit from close collaborations between clinical and basic science faculty, with unique training programs in diverse fields.

The successful candidate should have a demonstrated track record of leadership and research and teaching excellence with a proven reputation for effective interpersonal and administrative skills. The new Chair will facilitate collaboration and be expected to support the research, educational and interdisciplinary initiatives of the Department. The successful candidate will build on the strength and forward momentum of the Department's graduate and undergraduate programs and promote the development of new initiatives in research, scholarship and education. He or she must have a PhD, MD, DDS or equivalent, and will receive a tenured academic appointment at the level of Associate or full Professor. Candidates with a research program complementing existing research strengths are particularly encouraged to apply. The position of Chair is for a five-year term, renewable.

Western University is located in London, Ontario, with a metropolitan census of 530,000. As Canada's 11th largest city, London boasts an extensive educational and health care community. With full time enrollment of 32,000, Western graduates students from a range of academic and professional programs. Further information about the Schulich School of Medicine & Dentistry and Western University can be found at **www.schulich.uwo.ca**, and **http://www.uwo.ca**. Western's Recruitment & Retention Office is available to assist in the transition of successful applications and their families. Details about the Department of Medical Biophysics can be found at **http://www.schulich.uwo.ca/biophysics/**.

Interested candidates should submit a CV outlining their research, teaching, and administrative experience and interests, including future directions, together with the names and addresses of three referees to:

Dr. Michael Strong, Dean
Schulich School of Medicine & Dentistry
Room 3701A, Clinical Skills Building
Western University
London, Ontario N6A 5C1
FAX: (519) 850-2357
selection.committee@schulich.uwo.ca

Please ensure that the form available at **http://www.uwo.ca/facultyrelations/faculty/Application-FullTime-Faculty-Position-Form.pdf** is completed and included in your application submission.

Applications will be accepted until the position is filled.
Review of applicants will begin after September 30, 2015.

Positions are subject to budget approval. Applicants should have fluent written and oral communication skills in English. All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority. Western University is committed to employment equity and diversity in the workplace and welcomes applications from all qualified individuals, including women and men, members of visible minorities, aboriginal persons, persons with disabilities, and persons of any sexual orientation or gender identity.

UAB SCHOOL OF MEDICINE

Knowledge that will change your world

The University of Alabama at Birmingham

BIOCHEMICAL GENETICIST
Department of Genetics

The UAB Department of Genetics seeks applicants for a faculty position in the field of biochemical genetics. The Department of Genetics has an established biochemical genetics program consisting of clinical diagnostic and laboratories, and a clinical consultation service. Faculty rank will be Assistant or Associate Professor and may be either tenure or non- tenure earning. UAB faculty appointment and compensation are commensurate with qualifications and experience. Qualified candidates will have M.D. and/or Ph.D. credentials, and be board certified in Clinical Biochemical Genetics or Medical Biochemical Genetics.

This individual will be Director of the Biochemical Genetics Laboratory, and will also be responsible for teaching, research and/or clinical pursuits. Prior experience should include managing and interpreting biochemical lab results including standard biochemical testing and lysosomal disease screening and testing. Applicants with research interests will have demonstrated ability to conduct significant independent research, and a successful track record of grant funding.

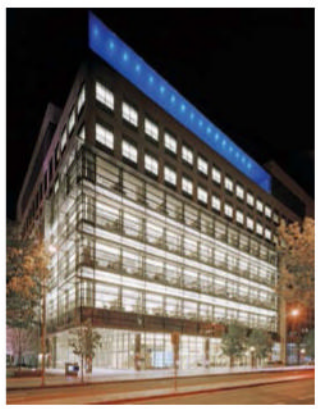
UAB is an Equal Opportunity/Affirmative Action Employer committed to fostering a diverse, equitable and family-friendly environment in which all faculty and staff can excel and achieve work/life balance irrespective of, race, national origin, age, genetic or family medical history, gender, faith, gender identity and expression as well as sexual orientation. UAB also encourages applications from individuals with disabilities and veterans.

A pre-employment background investigation is performed on candidates selected for employment.

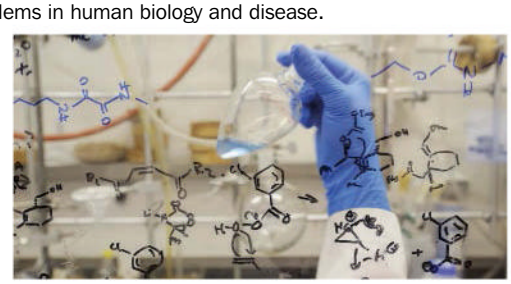
The University of Alabama at Birmingham offers an excellent benefits package including medical/dental insurance and dependent tuition. Interested applicants please send curriculum vitae including references, and a description of your teaching, clinical or research portfolio to:

Bruce R. Korf, M.D., Ph.D.
Professor and Chairman
c/o Dee Blakely-Stoudermire
UAB Department of Genetics
720 20th Street South, KAUL 230
Birmingham, AL 35294-0024
dblakely@uab.edu

BROAD INSTITUTE



The Broad Institute brings together a diverse group of individuals from across its partner institutions - undergraduate and graduate students, postdoctoral fellows, professional scientists, administrative professionals, and academic faculty. The culture and environment at the Broad is designed to encourage creativity and to engage all participants, regardless of role or seniority, in the mission of the Institute. Within this setting, researchers are empowered - both intellectually and technically - to confront even the most difficult biomedical challenges. The Institute's organization is unique among biomedical research institutions. It encompasses three types of organizational units: core member laboratories, programs and platforms. Scientists within these units work closely together - and with other collaborators around the world - to tackle critical problems in human biology and disease.



The Broad Institute is essentially an "experiment" in a new way of doing science, empowering this generation of researchers to:

- Act nimbly. Encouraging creativity often means moving quickly, and taking risks on new approaches and structures that often defy conventional wisdom.
- Work boldly. Meeting the biomedical challenges of this generation requires the capacity to mount projects at any scale - from a single individual to teams of hundreds of scientists.
- Share openly. Seizing scientific opportunities requires creating methods, tools and massive data sets - and making them available to the entire scientific community to rapidly accelerate biomedical advancement.
- Reach globally. Biomedicine should address the medical challenges of the entire world, not just advanced economies, and include scientists in developing countries as equal partners whose knowledge and experience are critical to driving progress.

Ryan W. Lavoie, JD Associate Director: Talent Acquisition
The Broad Institute of MIT and Harvard
75 Ames Street, Cambridge, MA 02142
E: **rlavoie@broadinstitute.org**
O: **617.714.8558** M: **603.583.1057**

Director, Division of Extramural Activities
National Eye Institute

The National Eye Institute (NEI), a component of the National Institutes of Health (NIH) and the Department of Health and Human Services (DHHS), conducts and supports research, training, health information dissemination, and other programs with respect to blinding eye diseases, visual disorders, mechanisms of visual function, preservation of sight, and the special health problems and requirements of the blind.

Are you an experienced Scientific Administrator in search of an exciting career opportunity? We may be the right place for you. The NEI at the NIH is seeking an exceptional Scientific Administrator to serve as the Director, Division of Extramural Activities (DEA). The Director, DEA, reports to the Director, NEI and serves as the principal advisor on research administration policies including peer review, grants management and administrative management of the Division. The incumbent oversees several distinct but related functions involving the extramural operations and has full managerial and executive responsibility for the following activities: Providing leadership and advice on extramural research grant, contract, and training program operations and policies within NEI; Providing oversight of grants management activities and implementation of grants policies; Providing guidance at the interface of grants management and the NEI Budget Office; Providing oversight and direction for the peer review of research applications, training applications and contract proposals. The incumbent represents NEI on extramural research administration and policy committees both within and external to NIH and HHS; Provides executive and managerial oversight of policy development for extramural research grant and contract review and management procedures; Provides overall management of the operations of the National Advisory Eye Council (NAEC) and serves as its executive secretariat and managing the resources for the DEA, including financial and personnel needs.

The Director, DEA will have responsibility for the development, implementation and dissemination of extramural review and grants management policies and procedures both internal and external to the NEI. The incumbent serves as an authoritative source on NEI extramural research peer review regulations, and grants management policies, and maintains awareness of new developments in research administration through interactions at professional conferences.

QUALIFICATIONS REQUIRED: Candidates must have an M.D., Ph.D., or equivalent degree in a field relevant to the position and substantial leadership experience in managing a federally-funded extramural science program. This position will be filled under a Title 42(f) excepted service appointment.

SALARY/BENEFITS: The salary for this position will be commensurate with qualifications and professional experience. A recruitment or relocation bonus may be available, and relocation expenses may be paid. A full package of federal Civil Service benefits is available, including: retirement, health and life insurance, long term care insurance, leave, and a Thrift Savings Plan (401K equivalent).

HOW TO APPLY: Submit a current curriculum vitae, bibliography, and full contact details for three references. In addition, applicants are asked to prepare two statements: a vision statement and a statement that addresses the specific qualification requirements (please limit both statements to two pages each). Send application package to Yireiza Williams at ywilliams@nei.nih.gov by September 30.

NEI will begin accepting applications from August 25th through September 30th and plans to have the position open for at least 30 days, but will not close the applicant process until a candidate has been selected.

Information about NEI can be found at **NEI.NIH.GOV**

You may contact Yireiza Williams with questions and for more information about this vacancy at **ywilliams@nei.nih.gov** or on (301) 451-1936.

HHS, NIH and NEI are Equal Opportunity Employers

NIH National Eye Institute (NEI)
Research Today...Vision Tomorrow

Director, Division of Extramural Science
National Eye Institute

The National Eye Institute (NEI), a component of the National Institutes of Health (NIH) and the Department of Health and Human Services (DHHS), conducts and supports research, training, health information dissemination, and other programs with respect to blinding eye diseases, visual disorders, mechanisms of visual function, preservation of sight, and the special health problems and requirements of the blind.

Are you an experienced Scientific Researcher or Scientific Administrator in search of an exciting career opportunity? We may be the right place for you. The NEI at the NIH is seeking an exceptional Scientific Administrator to serve as the Director, Division of Extramural Science (DES). The incumbent plans and directs programs of research grants, cooperative agreements, individual and institutional research training awards, and research and development contract support for basic and applied clinical research and training as it relates to blinding eye diseases, visual disorders, mechanisms of visual function, preservation of sight, and the special health problems and needs of individuals who are partially-sighted or blind. The incumbent has responsibility for directing and managing multiple extramural scientific program initiatives and functions, managing the domestic and international extramural funding activities of NEI and providing policy direction. The incumbent advises the Director, NEI, regarding basic vision research activities, and coordinates with other NEI, NIH and DHHS organizations and the extramural community to accomplish Institute objectives. Additionally, the incumbent provides executive and managerial leadership in setting extramural scientific priorities of the Institute, making broad and significant decisions on scientific programs, developing Institute-wide policies and procedures, and determining resource allocation issues involving a major component of the Institute and a significant portion of NEI funding. Through his/her expertise and experience, the incumbent must be able to promote, manage, and oversee extramural research activities of national and international significance.

The incumbent serves as the principal advisor and liaison representing the DES and NEI on NIH work groups and committees pertaining to extramural science programs and activities and represents the Institute in interactions with the extramural community and at national and international conferences and seminars.

QUALIFICATIONS REQUIRED: Candidates must have an M.D., Ph.D., or equivalent degree in a field relevant to the position and substantial leadership experience in managing a federally-funded extramural science program. This position will be filled under a Title 42(f) excepted service appointment.

SALARY/BENEFITS: The salary for this position will be commensurate with qualifications and professional experience. A recruitment or relocation bonus may be available, and relocation expenses may be paid. A full package of federal Civil Service benefits is available, including: retirement, health and life insurance, long term care insurance, leave, and a Thrift Savings Plan (401K equivalent).

HOW TO APPLY: Submit a current curriculum vitae, bibliography, and full contact details for three references. In addition, applicants are asked to prepare a statement that addresses the specific qualification requirements (please limit the statement to no more than two pages). Send application package to **Yireiza Williams at ywilliams@nei.nih.gov** by September 30.

Information about NEI can be found at **NEI.NIH.GOV**

You may contact Yireiza Williams with questions and for more information about this vacancy at **ywilliams@nei.nih.gov** or on (301) 451-1936.

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NIH National Eye Institute (NEI)
Research Today...Vision Tomorrow

EDITOR'S PICK

The steep learning curve of rocketry

From Anton Fletcher

Jeff Hecht says space is still hard (18 July, p 24). Indeed. The engines currently used to launch rockets work on the same basic principles as the V2 rockets of 1944. In the 1960s, these principles were refined into the mighty F1 engines that powered the Saturn V rockets, followed by the more efficient and powerful Russian-designed NK33 engines.

These use what is called a closed cycle, in which all propellant contributes to thrust. No one has yet built a more successful closed cycle engine, due in part to the failure of any American company to replicate the highly complex metallurgy necessary. Kuznetzov in Russia is very unlikely to restart production, even given a NASA contract.

The issue with all these engines is that they operate at the extreme limits of the capabilities of the materials available. And we just aren't building enough of them to enable the designs to be worked upon. It took over 100 years and the building of millions of machines to refine the modern piston engine, which has at least 10 times the power and longevity of those from the turn of the last century.
Droitwich, Worcestershire, UK

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Imagine there's no religion...

From David Flint

Joshua Howgego asks "What if... we find God?" (8 August, p 28). This ignores a much more plausible question: "What if... we all decide that God does not exist?". Non-belief, or at least indifference to religion, is already the default position in Japan and Western Europe. In the US it's the fastest-growing religious view.

If non-belief becomes the dominant view, we can expect religions to lose their political privileges in, for instance, public ceremonies and the UK's House of Lords. Religious belief will come to be seen as a species of intellectual error due to innate features of human thought such as our preference for living agents as the causes of events.

Once we cease to take seriously beliefs that defy logic, we will be much more able to criticise all forms of irrationalism: commercial, political and scientific as well as religious. This will not solve all our problems: nothing will. But it will remove an important barrier to such solutions.
London, UK

The editor writes:

■ Those wishing to explore more ramifications of a godless future can read our recent feature on this topic (3 May 2014, p 30).

From Bryn Glover

I found the tone of Joshua Howgego's piece a little odd. I am a non-believer for the reason that I have never seen evidence to support any sort of belief in any sort of supernatural entity.

However, if someone were to produce incontrovertible, reproducible evidence for the existence of God, then I would hope to be true to scientific method and unemotionally accept that evidence as reality.

The position of "anti-theists", and that of those who dismiss such proof as "impossible" seems to me to be as irrational as that of current theists.
Kirkby Malzeard, North Yorkshire, UK

Disembodied brain escape committee

From Chris Reynolds

Anil Ananthaswamy asks "What if... we don't need bodies?" (8 August, p 28). If my mind could be accurately simulated on a computer, my simulated self would be very annoyed if its ability to do arithmetic calculations were restricted to what my "old" biological brain would do, when there was a powerful and accurate calculating machine on the same circuit board. In fact my simulated brain, if not given direct access, would be busy trying to hack its way out of the simulation.

What simulated mind would want to be merely an accurate electronic model of its human source when it could be an intellectual giant with the enormous power and capabilities of a conjoined system?
Tring, Hertfordshire, UK

So you want to tell us about free will

From John Clark

You ask what would happen if we discovered we had no free will (8 August, p 28). Free will is an idea so bad it's not even wrong.

People, just like everything else, behave the way they do because of cause and effect and thus are deterministic, or they don't behave because of cause and effect and thus are random.

Tell me what the term "free will" means and I'll tell you what would result if we find out that humans don't have it.
Fort Lauderdale, Florida, US

A gene can do more than one thing

From Fiona Vincent

Michael Le Page writes that gene editing can make cattle hornless "without affecting any of their other traits" (15 August, p 10). Can we be sure of this?

In humans, a single gene is implicated in the illness thalassemia, so it might be considered desirable to edit it out. But the same gene also provides protection against malaria – a potentially valuable trait.
St Andrews, Fife, UK

What makes a planet 'Earth-like'?

From Brian Robinson

Yet again, excited astronomers and journalists are jumping up and down over finding "another Earth" (1 August, p 4). But Kepler-452b is not an Earth-like planet.

The Earth is part of a binary planet system, with the moon. The effects of being a binary planet have been suggested as major reasons behind the development of life.
Brentwood, Essex, UK

Jobs, not bogus training drivel

From Keith Walters

Lynne Friedli and Robert Stearn condemn the meaningless and inappropriate activities that unemployed people are forced to take part in, such as "building paper-clip towers" (18 July, p 24).

The same sort of bogus drivel has been padding the staff-training schedules of countless companies for years, and I suspect that managers are at long last expressing doubts about the excessively diaphanous nature of the emperor's wardrobe.

But the purveyors of this

"It's absolutely not a quantum computer by any definition outside D-Wave's own sales literature"

Richard Marshall isn't convinced by D-Wave's claims of qubit-crunching power (29 August, p 6)

"training" have apparently managed to reinvent themselves as the sure-fire answer to uncomfortable unemployment figures. About the only unemployment problem this is likely to solve is their own.
Riverstone, New South Wales, Australia

Neural network transparency

From John Vincent
Tamara Quinn suggests devising a way to monitor how neural networks arrive at their answers (Letters, 8 August). It is an interesting point and if a network could itself provide a case-by-case explanation that would be useful.

I worked on neural networks at British Telecom research labs in the 1990s, and one possibility could be to modify the system in order to gather evidence from the points of greatest "neural" activity. That information could then feed into a symbolic post-processing stage, for error detection and correction, and to package such data into verbal statements that would justify each classification.
Horsham, West Sussex, UK

Sundial is more backward than that

From David Muir
You write that sundials are aligned north (8 August, p 13). This is true in the northern hemisphere.

Readers in the southern hemisphere – where sundials are aligned south – may take umbrage at this hemispherism.
Edinburgh, UK

The sovereignty of the beasts

From David Carter
William Travers, in advocating an end to the wildlife trophy hunting industry, continues the tradition of overbearing Westerners forcing their religions and morals on the people of Africa (8 August, p 22).

I am embarrassed that the Australian government has the same attitude regarding lions. This year it clamped down on trade in lion trophies – a position at odds with that of the Convention on International Trade in Endangered Species.

We should respect the governments of African nations as the rightful managers of their wildlife. And we should support, rather than undermine, CITES, the treaty that for decades has effectively regulated world trade in wildlife according to objective ecological principles.
Evatt, ACT, Australia

Meet Superficial Intelligence

From Adrian Ellis
Martin Rees says that biological brains will eventually be superseded by superior machine intelligences (1 August, p 22). His remarks follows recent comments by Stephen Hawking and others, calling attention to the supposed dangers of runaway artificial intelligence.

These assertions all surprise me. The machine intelligence we currently see is more superficial than artificial. How do Hawking and Rees think these automated sorters and calculators will reach such lofty goals?
London, UK

How to hack aircraft after all

From Chris James
Iain McDonald reassures us that the flight crew can take over if an aircraft's computers fail or are hacked, and fly the plane manually (Letters, 8 August).

This would be fine at 30,000 feet, but what if the electronic attack took place at 300 feet during take-off or landing? Would the crew realise what had happened in time, and be able to take over and bring the plane under control before disaster struck? I very much doubt it.
Winchester, Hampshire, UK

TOM GAULD

For the record

- **And breathe. We meant to refer to *Astrobiology*, vol 15, p 119 (doi.org/6zc) when discussing ways that oxygen might appear on lifeless worlds (15 August, p 8).**
- **We reported tests for biomarkers of suicidality (22 August, p 10). These were tested by monitoring 265 men with psychiatric conditions, in two groups. One test involved trying to predict which of 108 men would develop suicidal feelings, the other looked at which of 157 would be hospitalised by an attempt.**

Letters should be sent to:
Letters to the Editor, New Scientist, 110 High Holborn, London WC1V 6EU
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PAUL MCDEVITT

FOLLOWING discussion of patent piracy in the sex toy start-up world (29 August), Michael Berkson is reminded that the UK patent office is well stocked with incendiary ideas. "I suggest patent GB 970091, 'Transmutation of Elements', which claims the synthesis of helium and the simultaneous generation of energy by mixing aluminium powder, solid sodium hydroxide and water in a steel pressure vessel," he writes.

Incredibly, this patent was granted to Noel Ignatius Rafferty in 1964. "To use a somewhat hackneyed phrase," writes Michael, "if the inventor were correct that Bethe's thermonuclear carbon cycle occurs within, I do not wish to be within one astronomical unit of the experiment."

STUDENT debt is spiralling ever higher, helped in no small part by companies willing to charge young learners vast fees and inflated textbook prices. Yet a special offer made to Marc Smith-Evans puts even these outsized costs into perspective.

"I was contemplating whether to upgrade my Microsoft Office package and came across this spectacular price for Office 365 for University: $1,567,239.33." The Home edition of the same software package was a relative snip at $99.99.

"I wonder whether this version includes all essays and exam answers," ponders a dejected Marc. "If not, I probably wouldn't admit to being a student."

FURTHER to our grasping for a handy name for contactless cards, Chris Williams writes: "Since the card is held above the reader and is likely to be used for rail travel and impulse purchases I suggest 'overpay'."

YOUR Truly Horrible Ideas for Saving the Planet continue to stink up Feedback's inbox. Roger Everest has a cut and dried plan to bring the world into equilibrium, writing: "My plan is to create a huge carbon sink by planting tobacco in the Sahara desert." To ensure long-term demand for this much leaf, smoking will be encouraged from the age of 10, and everybody on the planet will be supplied with 40 cigarettes per day, free of charge.

This idea will pay for itself by eliminating the need for pensions as well as the associated costs of caring for and housing the elderly.

"A further benefit will be the additional income taxes raised from growers, packaging, distribution and undertakers," writes Roger. Although he admits that the production and uptake of carbon dioxide will be net zero, he says the sequestration of millions of toxin-filled bodies will more than compensate.

MORE carbon sequestration: Andy Gillespie writes to locate the 2 kilograms of carbon that EcoStore claims are contained in every kilogram of their bamboo-derived plastic packaging (8 August). "While I share your scepticism over the true carbon-capturing properties of the product, this is basic chemistry.

"The bamboo absorbs and splits the CO_2 into carbon and oxygen as it photosynthesises. The O_2 is released and the carbon is incorporated into the bamboo's tissues, which ultimately becomes the feedstock for the plastic." As the molar mass of molecular CO_2 is around 44 g/mol, but pure carbon is only 12 g/mol, says Andy, "it seems perfectly possible for one kilogram of the material to have twice its weight of stored CO_2 equivalent".

CAUTION must be urged for EcoStore customers if reports from Catherine Gerrard are to be believed. She forwards a clipping for Nanobon Cooler, a horse rug built from "nanometer-level bamboo carbon".

As well as boasting a "minus ion effect" that will inexplicably neutralise lactic acid and balance blood pH in the wearer, the embedded bamboo charcoal within the blankets can, it is claimed, "release nature's far infrared ray to work with the body's existing ultra red to increase molecular vibration. This helps to keep the body warm from the inside." A perplexed Catherine asks, "I can only assume that ultra red is what most of us know as orange or yellow; but my horse is black and white, so will the rug still work on her?"

FEEDBACK readers continue to meter out unusual units. Paul McKinley shares the story of a manager who would rail against every obstacle with the common refrain "they can put a man on the moon but we can't…".

The building rang with this cry of despair so often that "putting a man on the moon" became a measure of the difficulty of a task. "That's a two man-on-the-moon job," Paul's colleagues would declare. The units of this measurement were, of course, "Armstrongs."

THE Edge is a building in Amsterdam with LED lights that communicate with workers'

smartphones, giving them control over the heating and lighting in their immediate area (15 August, p 18). Ray Norris is relieved to read that managers of the smartphone tracking system will not "monitor movements in the toilets".

He adds, "I trust they won't be monitoring the stream of people using the urinals either".

BMW warns that adults in the rear of the 3 Series "will find their knees touching the backs of the front seats, especially if two adults sit in front!" Ken Smith wonders if it's safe to let children drive…

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Poultry question

Are we making the threat of avian flu worse by killing infected birds? Would it make more sense to isolate them and let them develop immunity naturally? Or is bird flu so serious that they would all die anyway?

■ Your previous correspondent's reply to this, although correct as far as it goes, does not fully address the original question (25 July). The reason for mass culling is not so much to eliminate the virus as to minimise the risk of it spreading to humans. Breeding resistant poultry would completely eliminate the virus, and in a more effective way than culling flocks. However, flu viruses mutate very quickly, so a breeding programme might be too slow.

We take a different approach to plant crops. When wheat is infected by rust fungus, we do not destroy the whole crop, but replant the following year with a resistant variety.

Guy Cox
St Albans, New South Wales, Australia

Having a ball

We found this object by a sea wall in south-east Thailand. The white substance looks like a folded piece of fabric made out of limestone encrusted with glassy spheres. Only a tiny section of each sphere is attached to the limestone, but they are held firmly in place and cannot be removed with a fingernail. None of them has a surface scratch, which is impressive considering they must have been bashed by waves against the rocky sea wall. What are these tiny spheres?

■ This rock was originally an arkosic sandstone, derived from the weathering of granite. The glassy spheres are grains of quartz, embedded in a clay matrix. They are very rounded and highly polished, suggesting they have been carried and deposited in a high-energy environment, such as a powerful river or beach.

Although settings like these would account for the spheroidal quartz grains, they would not explain the white clay matrix, which is too fine to be retained in such an environment.

Arkosic sandstones are also rich in a class of minerals known as feldspars. As a result of post-burial reactions or deep weathering processes, the feldspars have been chemically altered by acidic conditions to form clay, in which the polished quartz grains find themselves embedded.

Because of the increase in volume that accompanies these feldspar reactions, all of the pores in the original sandstone are filled. The resulting rock is compact and quite structurally sound, despite being mostly clay.

Nice effect, nice rock – but just a rock.

Jeff Taylor
Melbourne, Australia

Nice rice

One often hears that it's not safe to eat reheated rice. Why is this? Surely anything that is living in the uncooked rice is killed by boiling it. If you then freeze the rice very quickly, it must be pretty much sterile and can be reheated when required. I've done this for years and am unaware of any ill effects. Am I dicing with danger?

■ *Bacillus cereus* is the most common cause of poisoning from reheated rice. It is found in soil, and the heat-resistant spores can survive boiling, allowing them to germinate when the rice cools.

Fortunately it seldom invades your organs, but infected rice toxins produced by the bacteria may cause nausea and a painful case of diarrhoea within hours of eating.

"It may be difficult to tell an acute attack from more dangerous types of food poisoning"

Healthy people generally recover in a day or two with no more treatment than staying close to a lavatory and drinking plenty of rehydrating fluids, but it may be difficult to tell an acute attack from more dangerous types of food poisoning. Some strains of *Bacillus cereus* may also themselves be dangerous, so don't complacently refuse to see a doctor if necessary.

These effects are largely avoidable. To forestall any problems, cook your rice until it's hot and eat it soon. If you want to keep any, prevent the bacteria from multiplying by either keeping the rice too hot to touch (60 °C or higher), or cooling it to fridge temperature (about 4 °C or lower) as fast as possible, even if that means putting it warm into your fridge or freezer. Such modest heat and fast cooling won't kill spores, but will prevent them from germinating and producing toxins.

Jon Richfield
Somerset West, South Africa

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